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BIDS FOR DEVELOPING WATER POWER on the Chicago drainage canal are wanted until Aug. 23. Two plants are proposed, the minimum volume of water in each case being 300,000 cu. ft. per min., which must be doubled by the district at some future date. At the Lockport site, an approximate head of 28 ft. will be available, only 35 miles from the heart of Chicago, to which point the district owns a right of way. At the Joliet site the available head will be 14 to 20 ft. The district owns and will provide land for a plant at each site. Bidders are invited to make "a single proposal for the creation of water power at each of these sites upon the lines of maximum development," and also to make a separate proposal for the installation of machinery, the district to provide the permanent works. Further details will be found in our advertising columns.

ELECTRIC POWER FOR OMAHA AND VICINITY, from the Platte River, is again under consideration. Mr. B. N. King, of Dayton, O., is said to be at the head of the project.

THE TRANSMISSION OF ELECTRIC CURRENT from Mechanicsville to Albany, along the canal, is probable, if the state will grant permission to the Hudson River Power Transmission Co.

PLANS FOR INCREASING THE WATER SUPPLY of Columbus, O., by building a dam and storage reservoir on the Scioto River, a few miles above the city, have been approved by the State Board of Health, but with conditions. The conditions are that the flooded lands be stripped of vegetation and the stored water purified to the satisfaction of the board. The board states that its investigations show the river "to be polluted by sewage beyond the limits of safety when considered as domestic water supply."

THE CHICAGO SEWER SYSTEM for the district bounded by 75th St., 87th St., Ashland Ave. and Lake Michigan is to be constructed by the city, but as this work will stop the sewage pollution of the Calumet River and consequently of the water supply taken in at the Hyde Park crib, the Drainage Board has agreed to maintain the pumping station until January, 1905. The sewage will flow to a pumping station at Stony Island Ave. and 75th St., and will there be pumped into an extension of the southern main intercepting sewer, described in our issue of April 21 and Aug. 25, 1898. By 1905, the new Calumet cut-off channel from the river to the main drainage canal will be completed, so that the flow in the Calumet River (as in the Chicago River) will be from instead of into the lake.

THE DISCHARGE OF EFFLUENT from the sewage filter beds of Summit, N. J., into the Passaic River is objected to by the city of Paterson, which has brought a suit to restrain that practice. The beds are at New Providence, some twenty miles above the intake of the Paterson water supply.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a derailment on the Philadelphia & Reading R. R. at Bucks Ridge, near Shamokin, Pa., on June 30, which resulted in the death of the fireman and the serious injury of the engineer. The train which was wrecked is known as the Cannon Ball Express, and it was running at a speed of 40 miles per hour when the leading trucks of the locomotive left the rails and the engine rolled down an embankment, dragging the baggage car with it. None of the passengers was injured beyond a severe shaking up. The cause of the derailment is stated to have been a large nut which had been placed on one of the rails.

THE LAKE STEAMER "MARGARET OLWELL" foundered during a heavy gale on Lake Erie on June 29, drowning nine persons. The vessel was laden with stone from Kelley's Island to Cleveland, and according to the reports of the survivors the cargo of stone shifted while the vessel was laboring in the trough of the sea. Shortly before she went down the rudder chains parted, allowing her to fall off into the trough. As the helpless craft rose on a heavy sea the stone slid to leeward, the steamer listed heavily and sank to the bottom.

TWO SERIOUS TROLLEY CAR ACCIDENTS occurred during the week. The first was a rear end collision on the lines of the Monongahela Traction Co., of Pittsburg, which resulted in the death of two persons and the injury of 15 others, five of them being seriously injured. According to the press despatches the accident happened on a steep grade near High Bridge. The two cars in collision were heavily loaded with passengers returning home from Kennywood Park. The motorman of the first car stopped near the bottom of the hill to get a drink of water at a spring near by. He had hardly left his car when the electric current, for some reason as yet unexplained, was shut off, leaving the car in darkness. Another car followed shortly afterward, and as the foremost car was in darkness it could not be seen until too late to check the speed. The rear car crashed into the other with terrific force, almost telescoping it. The second accident was a head-on collision on the Wilmington & Chester Trolley R. R., and it resulted in the injury of 14 persons. The collision is stated to have been due to the motorman disregarding signals.

THE STEAMER "KAISER FRIEDRICH" has been returned by the North German Lloyd Steamship Co. to her builder, F. Schichaw, on account of her failure to fulfil the speed guaranteed, which was that she should make an average speed of one-quarter knot per hour more than the "Kaiser Wilhelm der Grosse" of the same company, which now holds the world's record for the transatlantic passage. The "Kaiser Friedrich" is a little smaller vessel than the "Kaiser Wilhelm," but was designed to have sufficient power to develop greater speed.

THE LAKE STEAMER "ILLINOIS," which was put in service June 29, is 240 ft. long over all, 225 ft. long on the keel, 40 ft. beam and 17 ft. deep, with a draft of 12 ft. The hull is of steel, with three decks, and there is accommodation for 224 passengers. The screw is of the four-bladed sectional type, 11 ft. diameter and 15 ft. pitch. The triple expansion engine is of 1,500 HP., and has cylinders 20, 33 and 54 ins. diameter, with a stroke of 36 ins. Steam at 175 lbs. pressure is supplied by two Scotch boilers working under forced draft with closed ashpits. Two dynamos supply current for 500 incandescent lamps and a searchlight. The vessel is owned by the Northern Michigan Transportation Co., of Chicago, and will run between Chicago and Mackinac Island. It was launched (sideways) April 22, and started for its first trip June 29. The "Illinois" and its engines were built by the Chicago Shipbuilding Co., of Chicago, Ill.

THE BOSTON, CAPE COD & NEW YORK CANAL CO. has been authorized to issue stock to the amount of $140,000 and bonds to a like amount to pay the cost of the necessary surveys and right of way and for the deposit of $200,000 in cash with the State Treasurer required by law. Further issues of a total amount of $12,000,000 in stocks and bonds may be made when the stock is subscribed for and the bond issue is formally approved by the stockholders.

A NEW VIADUCT is to be built at Chicago to carry Canal St. over the tracks of the Chicago & Northwestern Ry. and Chicago, Burlington & Quincy Ry. The new viaduct will cost $19,000 more than a roadway viaduct of the present type, as it will be heavy enough to carry electric cars. The same railways have also agreed to repair and maintain the viaducts carrying Halsted St., Centre Ave., and Blue Island Ave. over their tracks. The decision was arrived at a recent conference between the Commissioner of Public Works and the railway authorities. The Commissioner considers that this shows that the railway companies recognize their liability for the repair and maintenance of the viaducts. He will confer with the officials of other roads in regard to similar arrangements for other viaducts.

A LARGE RAILWAY STATION has recently been completed at Edinburg, Scotland, by the reconstruction of what is known as the Waverly station. It covers 23 acres, of which 11½ acres are under roof. It has two main line platforms, two suburban platforms and 15 platforms for stub tracks, the total length of platforms being 13,980 ft. There are eight main tracks through the station, and 56 stub tracks and sidings. The 228 switches and 290 signals are operated by 538 levers in four signal towers, the largest of these having 260 levers. The number of people departing from and arriving at this station is estimated as at least 13,000,000 per annum, or 37,000 per day. On a busy day there were no less than 1,196 train movements, of which 649 were passenger trains. The others were empty trains, through freight trains and engines going to and from the water cranes and turntables.

THE TRAIN-ORDER ANNUNCIATOR for use on locomotives, which was described in our issues of Oct. 27 and Nov. 3, 1898, has been the subject of an interference case, involving the question of priority of invention, between Mr. Harry De Wallace and others. In May, 1898, the assistant examiner of patents decided against Mr. De Wallace, but on appeal the Board of Examiners reversed the decision. The other side then appealed to the Commissioner of Patents, who held that while Mr. De Wallace was the first inventor, he was not reasonably diligent in reducing to practice the issue of the patent on the air case. The patent covering his first application was then granted, but he took the matter to the Court of Appeals, which has awarded him the priority for the whole invention. He will now be granted the foundation patents on this device.

A BICYCLE RECORD of one mile in 57.8 seconds was made on June 30 by Chas. M. Murphy on a special track built between the rails of the Long Island R. R. near Maywood, L. I. The run was made in the rear of a car with a protecting hood extending 6 ft. to the rear of the car platform and close to the rail on each side, thus protecting the rider from any side wind. The space between the rails was covered with smooth pine planking. The special car was drawn by an engine whose driver was instructed to exceed a mile a minute, and the bicycler rode directly behind the car, keeping his wheel close to the rear buffer.

FURTHER EXPERIMENTS WITH OIL ON COUNTRY roads are reported as proposed by Major M. Meigs, of Keokuk, Ia. It is said that tests will be made in the vicinity of Des Moines to determine the effect of oil sprinkled on a road-bed well graded and crowned, harrowed lightly before and rolled after sprinkling. It is hoped that mud as well as dust will be lessened. Doubtless the grading, crowning and rolling will be very important factors in the test. All the reports state it is expected that the oil will cause the road to "shed water like a duck's back."

THE NEW GOVERNMENT TESTING TANK FOR SHIP MODELS AT THE WASHINGTON NAVY YARD.

By D. W. Taylor, Naval Constructor, U. S. N.*

The value of towing experiments upon small scale models of ships for the purpose of deducing the resistance of a full-sized ship from that of the small model, was demonstrated by the late Mr. William Froude, who, at his own expense, built a small tank for such experimental work at Torquay, England, about 1870. The English Admiralty subsequently recognized the value of his work and assisted him in it, later building a larger basin at Haslar, near Portsmouth, which is now in charge of his son, Mr. R. E. Froude. Other governments, notably Italy and Russia, were induced to establish model basins, which were largely copies of Froude's basin; and one firm of private builders, Denny Brothers, of Glasgow, Scotland, was sufficiently enterprising to build a basin for its own use.

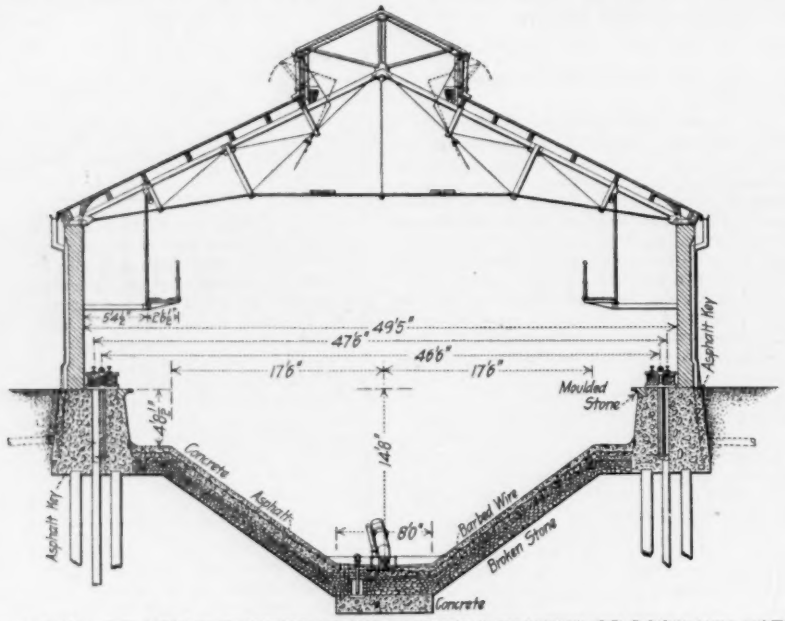


FIG. 1.—SECTION OF NAVAL TESTING TANK, SHOWING FRAMING OF ROOF AND DETAILS OF WATER BASIN, NAVY YARD, WASHINGTON, D. C.

The Construction Bureau of the Navy Department has appreciated for many years the value of an experimental basin, but it was for a long time unable to secure an appropriation for the purpose. Congress finally, about two years ago, granted $100,000 for this work, the grant being largely due to the efforts of the late Congressman Hilborn. The basin proper was completed the latter part of last year, and the special machinery and apparatus have now just been completed and installed, after a good deal of delay due indirectly to the war with Spain.

The basin is located in the southeast corner of the Washington Navy Yard, and is enclosed by a suitable brick building, shown in section in Fig. 1, which also illustrates the construction of the tank, and in plan in Fig. 2. This building is 500 ft. long and about 50 ft. wide inside, the only openings being the doors and the windows in the monitor. The water surface in the basin is slightly shorter than the building, being about 470 ft. long. The deep portion is about 370 ft. long, the south end, from which runs begin, being narrow and shallow. Fig. 2 gives sketch sections of the main portion of the tank and also sections of both ends. The water surface is 43 ft. wide, and the depth from the top of coping to the bottom of the basin is 14⅝ ft. The basin is considerably larger than any other in existence. The nature of the ground was such as to render the construction of a thoroughly tight and stable basin somewhat difficult, but owing to the small space available at the Washington Yard, it was necessary to locate it upon its present site. The bottom of the basin proper, shown in Fig. 1, and in detail in Fig. 2, is made up of a layer of broken stone about 12 ins. thick, upon which is a thin layer of concrete (about 3 ins.), then a half inch of Neuchatel asphalt, then about 9 ins. of concrete, in sections 16 ft. long, the keys between the various sections being filled with Bermudez asphalt, and the whole inside surface covered with the asphalt. The heavy side walls are 6 ft. thick at the bottom, 6 ft. deep, and about 4½ ft. thick on the top, not counting the molded stone coping. They are in 40-ft. lengths, with a square key-hole between adjacent lengths filled with Bermudez asphalt, as shown in the sketch, Fig. 2. The side walls rest upon a double row of piles, and in addition there is sheet piling completely around the deep part of the tank. The shallow part of the tank at the southern extension is also carried on piling, as it actually overhangs the water.

The contractors for the building and basin complete were the Penn Bridge Co., of Beaver Falls, Pa., and the sub-contractors for the concrete work and basin proper, the Cranford Paving Co., of Washington, D. C.

The law authorizing the construction of the model basin also authorized experiments to be made for private shipbuilders, provided they defrayed the actual cost of the same, it being understood, of course, that such experiments should not interfere with naval work. This being the case, it was necessary to lay out the plant with a view to the rapid and economical turning out of routine experiments, and to this end the endeavor has been throughout to use machinery for as many of the operations as possible. The foreign tanks invariably use paraffine for the construction of models, and generally make them from 10 to 14 ft. long. The climate of Washington, however, is so warm in the summer that it was found impossible to obtain paraffine that would retain its rigidity satisfactorily, and, moreover, it was the desire of the Bureau of Construction and Repair to make the models as large as possible, thus eliminating one source of inaccuracy in applying the model experiments to full-sized ships. For these reasons wood was adopted as a material for the models, and after some difficulty a satisfactory varnish was found which rendered the surface of the wood to all intents and purposes absolutely water-tight. The standard length of model used is 20 ft. A model 20 ft. long may not seem much larger than one 12 ft. long, but when it is remembered that the displacements of these two are respectively as 8,000 and 1,728, it will be seen that the 20-ft. model is nearly five times the size of the 12-ft. model.

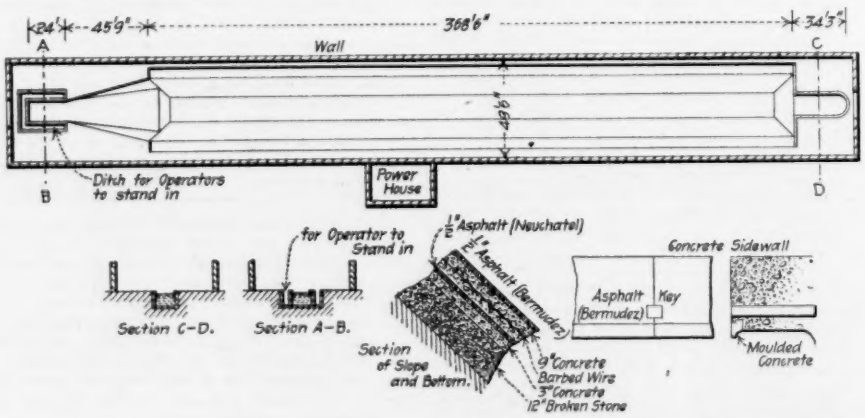


FIG. 2.—SKETCH PLAN AND SECTIONS OF BASIN AND DETAILS OF WATERTIGHT BOTTOM, AND METHOD OF JOINING SECTIONS.

The method of building the models is as follows: The "lines" of the vessel's hull as developed by its designers invariably include a body plan giving sections at moderately close intervals. From this body plan new sections are drawn to the proper size for a 20-ft. model, by means of the eidograph or large pantograph, shown in Fig. 3. These sections are cut out of paper, and then transferred to wooden boards which are sawed to shape. These boards are then erected in their proper relative position upon the erecting table, shown in Fig. 4, each board section being clamped in a vertical plane. They are then covered with battens about ½-in. thick, and tapering from amidships towards the end, making a "former" model, the surface of which is planed smooth. In cutting out the sections, allowance is made for the thickness of the battens, which have to be nailed upon them. Meanwhile, a rough block of such shape and dimensions that the finished model can be cut from it, has been prepared, by gluing together under pressure in a large hydraulic press, pieces of plank roughly cut to an appropriate shape. This block is placed upon the upper table of the model cutting machine, illustrated in Fig. 5 the "former" model being placed upon the lower table. The model cutting machine works upon the principle of the Blanchard lathe, a roller traversing the surface of the "former" model and saws or cutters working upon the surface of the model proper. The bulk of the material is removed from the block by means of the saws, which are shifted along a short distance at a time. Rotary cutters are then applied which finish the surface of the model very close to the desired shape. The model is then removed from the cutting machine and finished by hand; a very small amount of hand work, however, being found necessary. It is then ready for varnishing, and the attachment of any appendages, such as bilge keels, struts, etc. It is finally taken to the measuring machine, as shown in Fig. 6, and careful measurements are made of its exact form and shape, which not only enable the staff to determine whether the model represents the lines desired, but gives an exact record of the actual shape.

The model is now ready for the towing experiments. Figs. 7 and 8 show the carriage used in this work. It runs upon eight wheels and spans the full width of the basin, as shown in Fig. 7. The platform in the center carrying the recording apparatus can be raised or lowered at will. Elec-

*Bureau of Construction and Repair, U. S. Navy Yard, Washington, D. C.

tricity is used to drive the carriage, and it may be mentioned incidentally that it is used for all mechanical work in connection with the model tank. The speed of the carriage is varied not only by making various combinations of the four motors—one to each pair of driving wheels—but by controlling the output of the generator in the power station, which is, perhaps, 100 yards from the tank. This control is on the Ward-Leonard system, and is very similar to that used to control the motion of heavy turrets on board ship. By means of a resistance box on the carriage the current through the field coil windings of the generator is increased or decreased at will. The revolutions of carriage. The head of the cylinder has a round hole, and the piston rod is tapered so that as the rod is drawn out by the motion of the carriage the hole is gradually closed, the whole being almost exactly upon the principle of the hydraulic gun recoil brake. An escape is provided for the water around the piston when it starts from rest, to avoid sudden acceleration of the whole mass of water in the cylinder.

The dynamometric apparatus is designed to avoid entirely the use of multiplying levers or other devices involving the possibility of friction, and here again electricity is enlisted. The recording drum, Fig. 8, is, as usual, fitted with appa-

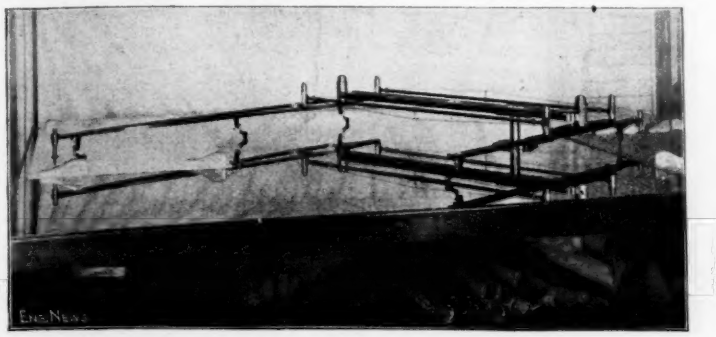


FIG. 3.—PANTOGRAPH USED TO ENLARGE HULL SECTIONS TO THE PROPER SIZE FOR A 20-FT. MODEL.

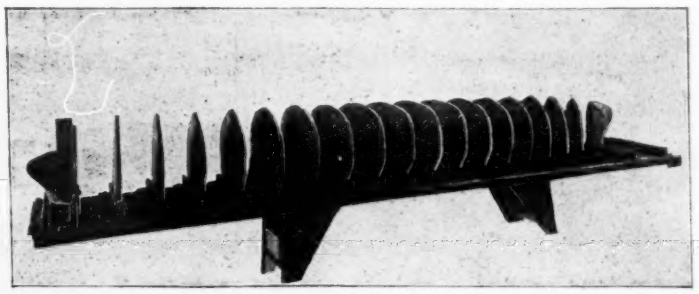


FIG. 4.—SPECIAL VISE TABLE FOR HOLDING HULL SECTIONS WHILE PUTTING BATTENS IN PLACE.

the generator being kept constant by a delicate governor, the amount of current generated varies with the amount of current through the field coils of the magnet. The whole of the current generated is passed through the motors, and in practice it is found that a very exact regulation of speed is obtained by this combination. The carriage itself, with its fittings, weighs in the neighborhood of 25 tons, so that it alone forms a kind of flywheel, and is not subject to sudden variations of speed. The speed of the carriage can be varied from 1-10 knot an hour, or 10 ft. per minute, to 20 knots an hour, or 2,000 ft. per minute. The principal difficulty in connection with the use of high speeds, which, while not necessary for the bulk of the experiments will be of great value in certain special experiments, is to stop the carriage when it is once under way. The electrical control acts as a brake, because when the current is shut off the motors become generators, but this could not be relied upon for high speeds, since the sudden rush of current due to possible unskilful manipulation, might throw the circuit breakers, thus opening the circuit and cutting off the current entirely. For these reasons there is at the north, or terminal end of the basin, a double system of brakes to catch and stop the carriage. The first is a friction brake consisting of two strips of iron on either side pressed together by hydraulic cylinders. These are forced apart by a slipper on the carriage about 10 ft. long, which, as well as the brake strips, is kept thoroughly oiled, so that the coefficient of friction for stopping, though low, is fairly definite and sudden jerks are avoided. The pressure in the hydraulic cylinders is controlled by an accumulator and a pump driven by electricity. Great care has been taken in connection with this part of the installation that it may be always in working order, and any trouble or breakdown, except that of the pump itself, which runs all the time, will simply result in setting the pressure at a maximum. This maximum is 600 lbs., but it has been found by actual experiment that with 500 lbs. pressure the carriage is brought safely to rest when it enters the brakes at a speed of 20 knots. It is not expected in practice to repeat this often, since even for the high speed runs the electrical brake will be used to reduce the speed of the carriage before the friction brake is used. In addition to the friction brake, there is what is called the emergency brake, so that in case the friction brake fails for any reason, the carriage would still be caught. This brake consists simply of a piston about 16 ins. in diameter, working in a cylinder which is submerged in the water of the tank and connected by wire cables to a hook which takes hold of the ratus for recording the time and distance. The resistance is measured directly by a spring arrangement, which is placed underneath the carriage. The forward end of the spring is attached to a bracket which is screwed forward or back by an electric motor, and a rigid arm runs up from the bracket, with a pencil recording its position on the drum. The record then is of the position of the forward bracket. The after end of the

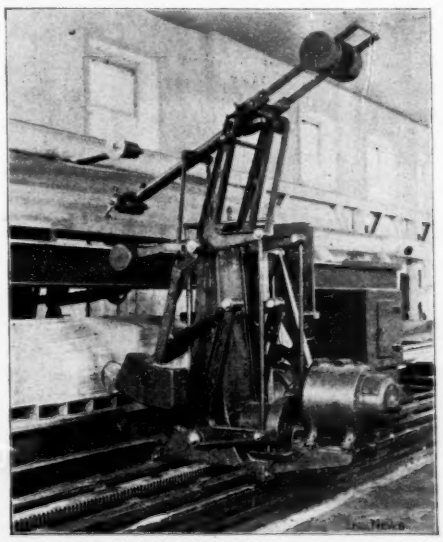


Fig. 5.—Routing Machine Used to Shape Models.

spring takes hold of a small cross-head to the other end of which again is attached a towing rod, which takes hold of the model. This cross-head has a very slight play between stops in the after fixed bracket, and when it touches either stop closes an electrical contact which again throws an electric clutch, by means of which the motor, running all the time, screws forward or back the forward bracket, thus increasing or decreasing the tension of the spring until the contact is opened again.

There are many refinements which cannot be indicated in this brief description; for instance, the operator can throw either clutch at will or set them to work automatically. In practice, when about to make a run, the operator works the bracket forward to the immediate vicinity of the position which he knows it will assume during the run, the approximate speed of which he knows. The carriage is then started, and after a uniform speed has been obtained, which, for speeds up to 12 knots, is done within 50 ft., he throws in by a single motion of one handle the automatic appliances which start the drum, Fig. 9, and record time, distance and resistance. In this way the resistance pen has to move but a small distance to reach the position of equilibrium and almost immediately becomes steady. It will be seen that with this device friction is eliminated. The accuracy obtainable depends upon the closeness with which the automatic stops at the after end of the spring can be set. In practice it is found that those can be set to give a play of about 1-50 of an inch, and as the springs will extend 10 ins., the results obtained are practically exact as indicating the pull of the spring.

It now remains to describe the method by which the amount of this pull can be determined in any instance. There is fitted at the starting end of the basin a kind of weighing machine with one vertical and one horizontal arm. This is delicately balanced, and when the model has been connected up and is ready for towing, a certain spring being in use, the vertical arm, or rather a knife-edge which bears upon the vertical arm, is connected to the model. A known weight is then put into the scale pan attached to the horizontal arm. The automatic attachment in connection with the dynamometer spring is thrown into gear and the weighing machine is screwed forward or backward until it is in perfect balance, and the record pen recording the position of the spring is at rest. It is evident then that the pull of the spring is exactly equal to the weight in the scale pan. There are a number of pens which can be shifted parallel to the recording pen and set in a definite position to record upon the drum. One of these pens is set to correspond to the position of the resistance pen, then another weight is put into the scale pan, a second pen set to record the resistance, and so on. It is evident then that when the run is made these fixed pens mark off upon the paper a scale for resistance, avoiding all complications of corrections for temperature of spring or anything else. A complete double outfit of springs is already provided for measuring resistance from 1 up to 500 lbs., and for special work additional special springs will be obtained.

In connection with the question of temperature, it is impossible to avoid a certain variation of the temperature of the water, but as ample heating facilities are provided, as indicated in the pictures of the building, Fig. 7, where the heater pipes are shown, it is not expected that the variation of temperature during the year will be sufficient to necessitate correction in the results of experiments on this account. The basin is filled from the water system of Washington, and will hold 1,000,000 gallons. Two electrical centrifugal pumps are provided, the larger of which will empty the tank in about four hours. The smaller pump is a 4-in. pump used for draining the last water from the basin, and also for pumping the water from outside the basin to avoid the possibility of undue pressure upon it in case it is left empty for some time. This is necessary, since the basin is but a short distance from the Potomac River, and extends 8 or 9 ft. below mean low tide level. A gage indicates the level of the outside water, which is found to be, as a rule, about 6 ft. below the water in the basin.

The leakage from the basin, which is very slight, and the evaporation, are made up with filtered water, an animal bone filter being installed with a capacity of from 50 to 100 gallons per minute,

depending upon the turbidity of the water. In practice a small stream of fresh filtered water is kept running into the basin all the time, and the level is maintained wherever desired by an adjustable overflow.

The building and tank or basin proper, as well as the machinery for making models, were designed by the Bureau of Construction and Repair. The electrical installation was fitted by the General Electric Co., Schenectady, N. Y., many of the electrical details of design being also due to them. The carriage proper was built by the William Sellers Co., Philadelphia, Pa.; the dynamometer apparatus partly by the Sellers Co., and partly by Saegmuller, of Washington, D. C., who also built the large eidograph. All of these are upon the designs of the Bureau of Construction and Repair. The model cutting machinery was built by Detrick & Harvey, of Baltimore, Md., to the designs of the Bureau of Construction and Repair.

The model basin staff is now at work upon experiments to determine frictional coefficients of varnished surfaces and other constants needed in its use. Experiments are being made as opportunity serves upon models of the naval vessels already built and tried for the purpose of accumulating data which will be constantly needed during the life of the tank. As soon as preliminary lines of the new third-class cruisers authorized at the last session of Congress are completed, experiments will be made with them in the tank with a view of introducing any refinements or improvements found desirable.

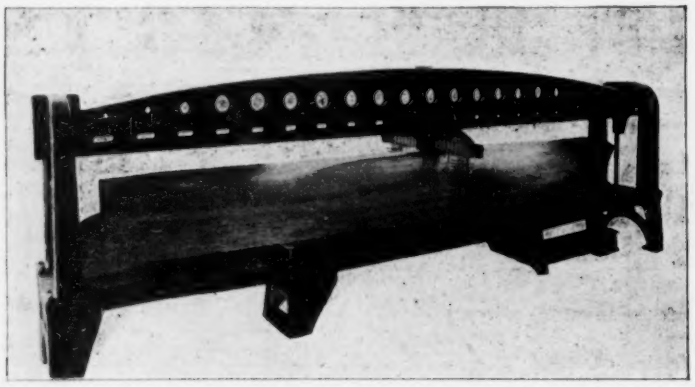


FIG. 6.—GAGING MACHINE FOR DETERMINING SECTIONAL DIMENSIONS OF COMPLETED MODELS.

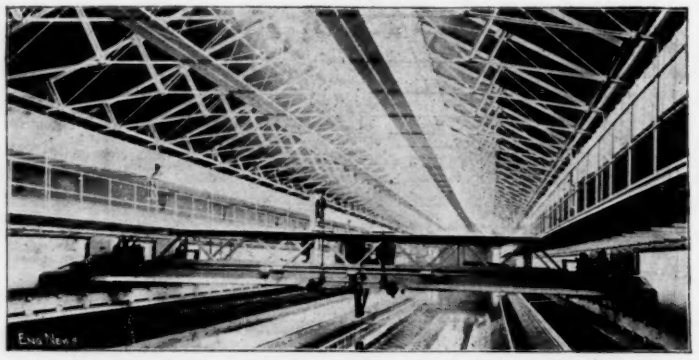


FIG. 7.—GENERAL VIEW OF THE INTERIOR OF THE BUILDING, SHOWING THE TOWING CARRIAGE.

LOGARITHMIC DIAGRAM FOR FLOW OF WATER IN CLEAN CAST-IRON PIPES UNDER PRESSURE.

(With two-page plate.)

In our issue of Sept. 22, 1898, we reproduced in a simplified form a logarithmic diagram from "Le Genie Civil" for estimating the flow of water in cast-iron pipes under pressure. The diagram was devised by Mr. A. Van Muyden, C. E., and described by Mr. Jean Rey. In 1884, Mr. Van Muyden based his diagram on the Darcy experiments of 1857, but in a new edition of the work in which this diagram appears, he makes use, instead, of the formula of Mr. Maurice Levy, extending its applicability to diameters of 3 m., or 118.11 ins.

The diagram reproduced last September gave sizes, lengths and other factors in the metric system, and was, therefore, extremely inconvenient for the use of most American engineers. A great service has been rendered to the profession by Mr. Geo. T. Prince, M. Am. Soc. C. E., Chief Engineer of the Omaha Water Co., of Omaha, Neb., who has reconstructed the diagram with American measures, and has kindly sent it to the Engineering News for the benefit of its readers. It will be found reproduced on the two-page plate in this issue. Mr. Prince states that for pipes 4 ins. in diameter and over, the diagram gives results very closely approximating to those published by Mr. E. B. Weston, M. Am. Soc. C. E., as derived from the Darcy formula. Below 4 ins., the diagram gives figures more like those from the Poncelet formula.

The following matter regarding the use of the diagram has been sent us by Mr. Prince:

Many of the problems relating to the flow of water in pipes can be solved by means of this diagram with sufficient accuracy to meet the requirements of ordinary practice.

Case I.—Given the discharge and diameter of pipe to find the frictional loss and velocity of flow. Find the amount of discharge in the column headed "Discharge in U. S. gallons per minute," and follow along the inclined line to its intersection with the horizontal line indicating the given diameter, the vertical line passing through this point of intersection indicates the amount of frictional loss per 1,000 ft., and is to be read at the top of the diagram.

The lines which are inclined, approximately, 45° indicate the velocity of flow in ft. per sec.; hence, a line drawn parallel to these, through the point of intersection between the lines of discharge and diameter of pipe, will indicate the velocity of flow, and is to be read at the bottom of the diagram.

Example: Given a discharge of 500 gallons per min., through a 12-in. pipe, what is the frictional loss and velocity of flow in feet per second?

Fig. 8.—Recording Drum, Observers' Seats and Controlling Switchboard on the Moving Carriage.

Following along the inclined line marked "500 gallons per min." to its intersection with the horizontal line designated "12 ins. diameter," we find the frictional loss, as read at the top of the diagram, to be a little over 0.65 ft., say, approximately, 0.67-ft. We also find that this point of intersection is between the oblique lines indicating respectively 1.0 and 1.5 ft. per sec. velocity of flow, and is approximately 1.4 ft. per sec.

Case II.—Given the discharge and frictional loss in head per 1,000 ft., to find the required diameter of pipe and velocity of flow.

Find the point of intersection between the vertical line indicating the given frictional head and the inclined line corresponding to the given discharge, the horizontal line through this point designates the required diameter of pipe and is to be read on the side of the diagram. The velocity is determined as in Case I.

Example: Given a discharge of 1,500 gallons per min. and frictional resistance or loss of pressure of 1.4 ft. per 1,000, what is the required diameter of pipe and rate of flow?

We find by inspection of the diagram that the inclined lines indicating 1,500 gallons of discharge, intersects the vertical line marked "1.4 ft.," on the horizontal line corresponding to 16-in. pipe; hence, that is the required size of pipe to fulfill conditions. From the position of this point of intersection with the oblique lines, it is apparent that the rate of flow would be about 2.4 ft. per sec.

Had the frictional head been slightly less than 1.4 ft., say 1.1 ft., we would use the next larger size of pipe, or 18-in., with a slightly less velocity of flow, about 2.2 ft. per sec.

Case III.—Given the frictional loss in pressure and the diameter of pipe, to find the discharge and rate of flow.

Find the point of intersection between the vertical line indicating the given frictional head, or loss in pressure, and the horizontal line corresponding to the stated diameter of pipe, a line drawn through this point parallel to the inclined lines designating discharge will determine the discharge, and is to be read at the side of the diagram; in like manner the rate of flow is read at the bottom of the diagram.

Example: Assume a frictional loss of 2 ft. per 1,000 ft., and 30 ins. as the diameter of the pipe, what is the discharge and rate of flow?

The point of intersection between the vertical and horizontal lines corresponding to the conditions stated is between the inclined lines indicating 8,000 and 10,000 gallons discharged per min., and it is sufficiently accurate to meet the requirements of ordinary practice to consider the discharge in this case as 9,000 gallons per min. The rate of flow will be noted as practically 4 ft. per sec.

Case IV.—With the frictional loss and rate of flow given, the proper size of pipe to be used and its discharging capacity can be ascertained from the diagram at a glance.

For instance, with a frictional loss of 2 ft. per 1,000 ft. and a rate of flow of 3 ft. per sec., we would require an 18-in. pipe, and under these conditions it would discharge about 2,300 gallons per min.

The above problems are a sample of the many that constantly arise in the experience of those having in charge the design, construction and maintenance of water plants, which can be quickly solved by the use of the diagram with sufficient accuracy to fulfill the conditions of ordinary practice.

It should be remembered, in determining the size of pipe requisite to discharge a given quantity of water, that suitable allowance should be made for the increased resistance that will arise because of corrosion and formation of tubercles within the pipe, tending to reduce the discharge. It is a safe rule to add 25% to the required discharge and select the pipe, accordingly.

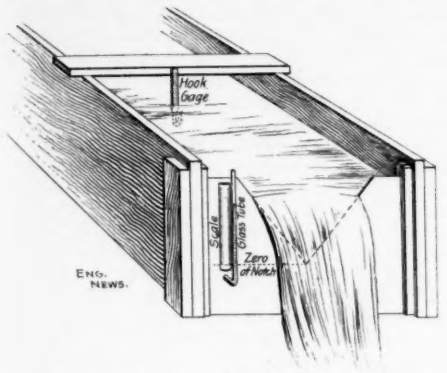
SECOND TEST OF A 14-IN. RIVETED STEEL MAIN AT NEW WESTMINSTER, B. C.

By A. McL. Hawks, C. E.*

In Engineering News of July 30, 1896, the author described a test of the capacity of this pipe made in April, 1896, under similar conditions, but with less head. To this article the reader is referred for the detail of pipe construction, and the alinement and gradients. It is sufficient to say here that the obstructions to flow were as follows: (1) The longitudinal rivets along the lower quarter of the pipe; (2) the circles of circumferential rivets, about 3½ ft. apart; (3) the lap of the transverse joints, about 3½ ft. apart; (4) the rivets at the reinforcing rings, 24 ft. apart. The pipe itself was made of soft steel, 14 ins. interior diameter of inner ring; all rivets ¼ in. diameter with circular or "snap" heads. The main was 70,700 ft. long.

*Tacoma, Washington, P. O. Box 898.

Before making this test the pipe-line was examined, to be sure that there was no accumulation of air at summits, or mud deposits in the depressions. An observer was stationed at the screen chamber, at the inlet, to gage the height of water at that point while the weir tests were in progress at the reservoir. The water had been drawn down in the reservoir by reason of water run from taps during cold weather, until the inlet pipe was sufficiently bare to permit a weir-box to be built about it. This box was 22 ins. wide in the clear; 20 ins. deep, and 9 ft. 3 ins. long on the bottom. It was made of clear, dressed lumber, and at the outer end was placed a 90° notched weir-plate, made of 20-gage sheet-iron, with the bottom of the notch 10 ins. above the floor of the weir. Water flowed through this notch 8.9 ins. deep, leaving about 2½ ins. space between the walls of the weir-box and the nearest point upon the weir-plate when the water was flowing. As the sectional area of the box was about 3 sq. ft. and the discharge less



A Glass Gage for Measuring the Depth of Water Flowing Over a Weir.

than 1.25 cu. ft. per second, the velocity of approach was not over 4 ins. per second; or, less than the 6 ins. noted by Mr. Francis. The error was thus about 1%, and was disregarded.

Thompson's formula for discharge with triangular notches was employed. With this and h = 8.9 ins. — discharge in cu. ft. per sec. = $.0051 \times \sqrt{h^5} = .0051 \times 237 = 1.209$ cu. ft.

At the same time that the weir test was in progress a volumetric test was made by flowing, for 4 h. 5 min., into the reservoir; the clear outfall from the lowest point of the notch being over one foot at the end of the test. The reservoir filled 16.1 ins. in 245 min. over an average area of 13,149 sq. ft.; or a total volume of 17,700 cu. ft., 80 cu. ft. having been allowed for voids in the broken stone paving on the bank. This inflow gives a rate of 1.204 cu. ft. per sec.

Using Kutter's formula for this discharge and taking n = .013, with the observed head of 430.3 − 389.0 = 41.3 ft., in 70,700 ft., the length of the pipe, S = 41.3 ÷ 70,700 = .000584;

$$V = C\sqrt{R\,S} = 87\sqrt{.292 \times .000584} = 87 \times .0132 = 1.148 \text{ ft. per sec.}$$

Discharge = 1.069 × 1.148 = 1.227 cu. ft. per sec.

These three determinations are very close together, and it will add to their value to compare them with the former test referred to. In that test a square-lipped weir was used in thin plate, and all the conditions were favorable for employing the Francis formula. In that test $D = 3.36 \times (l - \frac{1}{10} h) \times \sqrt{h^3} = 0.96$ cu. ft. per sec., l being the length of the weir in feet and h the head of water over the weir in feet. By volumetric test the water rose 0.35 ft., in 2½ hours, over an average area of 25,225 sq. ft.; or say, 8,900 cu. ft. (allowing 65 cu. ft. for voids in paving), in 9,000 seconds; or at the rate of 0.99 cu. ft. per sec. Using Kutter's formula for this discharge, and taking n = .013, with the observed head of 429.15 − 396.95 = 32.2 ft., in 70,700 ft., we have

S = 32.2 ÷ 70,700 = .000455;

$$V = C\sqrt{R\,S} = 87\sqrt{.292 \times .000455} = 87 \times .0115 = 1.0005 \text{ ft. per sec.}$$

Discharge = 1.069 × 1.0005 = 1.07 cu. ft. per sec. When the difference in head is considered, and these separate sets of tests are compared, they practically agree with each other, and would indicate that the coefficient of friction, n = .013, is not far from correct for such a main with low velocities. It also shows that deterioration goes on very slowly in steel mains when they are thoroughly coated. With n = .013, the calculated flow was 8% too great in 1896, when the main had been in use four years; and less than 3% too great in 1899, when it had been in use seven years.

In making the weir test the author introduced a novel measuring gage, to take the place of the hook-gage. A glass tube, 24 ins. long and ¼-in. diameter, was bent at right angles at the center. One arm of this was passed through a hole bored in the face of the weir, opposite to and a little below the notch in the weir-plate. The other and outer arm rose vertically, parallel to and about ½-in. distant from the face of the weir. Behind this gage, with its zero coinciding with the zero, or bottom of the notch, was placed an ordinary white-faced drafting scale, divided into twentieths of an inch. On this the depth of the notch was read directly, instead of inversely, as with the hook-gage. The fluctuations could be closely observed, and the best average taken; and although it entered into the water of the box a little less than one foot, it agreed exactly with the hook-gage readings taken on a cross-bar 3 ft. 6 ins. back from the face of the weir. The top of the water in the tube took a concave form 1-10-in. deep, half of which may be taken as the true surface of the water in the weir-box.

LEGISLATION FOR THE PROTECTION OF PUBLIC WATER SUPPLIES IN NORTH CAROLINA.

Additional protection of public water supplies in North Carolina is provided for by Chap. 670 of the Laws of 1899. This act provides for a sanitary inspection, at least once every three months, of drainage areas from which water supplies are drawn, the inspection to be made by an employee of the water company or municipality owning the works and at the expense of such owner. In the case of works deriving their supply from lakes or ponds, or from small streams not more than 15 miles long, sanitary inspections of particular localities in drainage areas must be made once a month if in the opinion of the local board of health there is reason to fear "infection of the water by that particular locality," and once a week where "there is special reason to apprehend the infection of the water from that particular locality by the germs of typhoid fever or cholera." In case there is no local board of health the county superintendent of health, or the state board of health, may order these special inspections.

Where water is drawn from streams having a minimum flow of 10,000,000 gallons a day the provisions just cited apply "to the 15 miles of watershed draining into the said river or creek next above the intake of the water-works."

The apparent meaning of this clause would be expressed better by saying, the adjacent drainage area for a distance of 15 miles above the intake. In addition to the requirements outlined, each water company and city owning waterworks must, at its own expense, at least once each three months, secure chemical and bacterial analyses of samples of water drawn from a faucet used for drinking purposes, provided that water from artesian wells shall be analyzed at the discretion of the secretary of the state board of health, but not oftener than once each year.

Water companies failing to have sanitary inspections made as provided by this act are liable to deductions of $25 for each offense, up to a total of $500 in any one year, from their bills against the city. Where works are owned by a city fines of $10 to $25 may be imposed, or 10 to 30 days' imprisonment, upon the official in charge of the works, unless he can show that a superior officer prevented him from making the inspection; in which case the superior officer becomes liable to a fine of $50 to $200, or 1 to 6 months' imprisonment. Omissions made by city officials are declared to be misdemeanors.

Besides this new law the general health act of the State contains two sections for the protection of public water supplies. One of these provides that the pollution of any source of water supply shall be a misdemeanor, punishable by a fine not exceeding $1,000 or imprisonment not exceeding one year. The other section makes it a misdemeanor to neglect to disinfect the excreta of cholera or typhoid patients, the penalty being from $2 to $25, or 10 to 30 days' imprisonment, increased to $25 to $50, or not over 30 days' imprisonment in case undisinfected excreta from such patients are emptied on the drainage area of a public water supply. Any physician attending a case of cholera or typhoid fever who fails to give proper instructions regarding disinfection as soon as the diagnosis is made becomes guilty of misdemeanor and liable to a fine of $10 to $50.

The new act and the two sections of the general health act from which the above statements have been drawn are published in the "Bulletin of the North Carolina Board of Health" for May, 1899, copies of which may be obtained, we presume, by sending a request, accompanied with a 1-ct. stamp, to Richard H. Lewis, M. D., Secretary State Board of Health, Raleigh, N. C.

TAIL RACE OF THE CHICAGO DRAINAGE CANAL.

When the Chicago main drainage canal is completed, the water flowing through it will be discharged into the channel of the Desplaines River, and one of the important accessory works of the canal will be the tail race connecting its lower end with the Desplaines River. The discharge from the main canal into the tail race will be regulated by a bear trap dam and a series of 15 sluice gates, as shown in Fig. 1, and as described in our issues of Nov. 21 and Dec. 12, 1895, and March 24 and May 26, 1898. In the latter two articles, however, there were some inaccuracies, due to the fact that since their preparation the plans of the tail race had been materially changed The tail race forms Section No. 16 of the canal.

Several routes were proposed and investigated, and when the time came for the preparation of definite plans for this part of the work, it was seen that there was a great opportunity for the development of power by the water flowing from the canal, as noted in our issues of Sept. 2 and Dec. 23, 1897. This power could readily be made available for lighting and power purposes in Chicago or Joliet. After lengthy negotiations the western route was adopted, owing partly to the excessive prices demanded by the owners of land on the shorter (or "central") route. By the plans, as adopted, about 15,000 HP. would have been developed at maximum flow. Mr. Randolph, the Chief Engineer, strenuously opposed the final adoption of the "western" route, on the ground that by this route the development would be only a partial utilization of the power available from the flow through the drainage canal, and that such partial development would effectually prevent the development of the maximum power. Under the maximum development the flow of 300,000 cu. ft. per minute should develop about 16,000 HP. net, while with the maximum future flow of 600,000 cu. ft. of water per minute there could be 26,000 HP. developed.

Plans were made and bids invited for work on the "western" route, but in November, 1897, it was finally decided, on the recommendation of the Engineering Committee of the Sanitary District, to abandon these plans in favor of what was known as the central route. Another reason for this change was that the owners of property on the shorter (or central) route, who had demanded excessive prices, had offered to accept more reasonable terms when they found that bids had been called for construction on the other route. The cost of the longer route was estimated at $622,000 (including $100,000 for the development of wheel pits, etc., for the water power plant). The estimate for the shorter route was $265,000 (including $90,000 for construction and $175,000 for right of way), making a saving of $357,000 in favor of the route now adopted.

According to plans which have been outlined under the direction of Mr. Randolph, there will be 7 ft. less head of water with the maximum flow than with the minimum flow. This is the difference in the hydraulic slope required for the two flows.

What he regarded as of vital importance was

the acquisition by the Sanitary District of all the property necessary to give it the absolute control of the situation, and this has been done. As soon as the money is available for this larger development it can be accomplished without hindrance from outsiders. In Joliet, under the recent Decree of Court, the District is barred from any water power development at the site of Dam No. 1, but at the mouth of Hickory Creek, two miles down stream, it can secure a head of 16 ft. for power development.

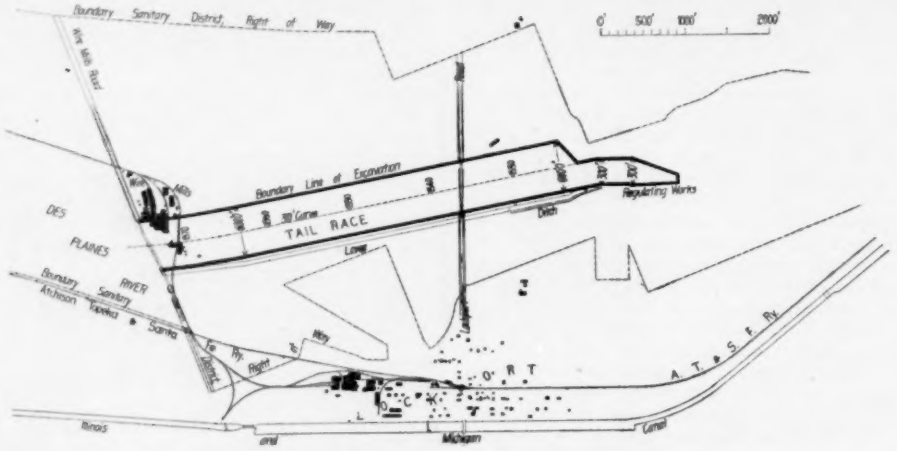


FIG. 1.—PLAN OF TAIL RACE OF CHICAGO DRAINAGE CANAL.

Original Plan for Tail Race.—The plan of the route now adopted, and known as the central route, is shown in Fig. 1. The abandoned western route kept nearer the west side of the valley and clear of the wire mills, beyond which it extended for some distance. The width of the tail race was to be 400 ft., with a length of about 10,500 ft., or nearly two miles. The depth was to be 16.2 ft. below the top of the embankment, the bottom having a grade of 0.4 per 1,000. At the south end of the tail race was to be a weir dam of concrete, faced with masonry, forming a basin, the water from which would flow over a water-power dam in the east side of the channel, or over the weir dam if the level rose above a certain stage. The weir dam was to consist practically of two dams almost at right angles to one another, having heavy abutments at the ends and in the angle. Both parts were to be curved. The larger portion, extending across the end of the tail race, was to be 1,124 ft. long on the crest, with a chord of 1,100 ft., a middle ordinate of 100 ft., and a radius of 1,562 ft. The shorter portion, forming part of the east side of the tail race, was to be 502.3 ft. long on top, with a chord of 500 ft., a middle ordinate of 19.7 ft., and the same radius as the longer portion. The overflow crests of the weir and power dams were to be 15 ft. 6 ins. below Chicago datum. The weir dam was to be of somewhat peculiar construction, built in sections 15 ft. long, any one section being completed before the construction of an adjacent section, so that the dam would consist practically of monolithic concrete blocks 15 ft. long and the full height of the dam. The joints were to be made with mortar.

Present Plan for Tail Race.—The tail race as now being built will be shorter and much less expensive than the one above described. It will be about 6,500 ft. in length, with a normal width of 600 ft., a depth of 11 ft. from the top of the embankment, and a bottom grade of 1 to 1½ per 1,000. Opposite the regulating works the width will be only 300 ft., and will decrease to 100 ft. at the extreme north end. Fig. 1 is a plan and Fig. 2 a profile of the tail race. Two highways will have to be carried across the channel, as shown by Fig. 1, and the profiles of these are given in Fig. 3, while Fig. 4 shows the typical cross-sections of road and embankment construction.

On the east side of the tail race, and extending for its full length, there will be an embankment or levee 50 ft. wide on top and having its toe 50 ft. from the edge of the channel. This will have an earth core, with a filling of broken stone on each side, as shown in Fig. 4. The crest will be 4 ft. above high water line. A drainage ditch having a bottom width of 8 ft. will extend along the east side of the embankment from the regulating works to the Des Plaines River, and this will be 20 ft. from the embankment. The road approaches to the bridges on the Lockport road and Wire Mills road will be of broken stone, having a top width of 30 ft. and side slopes of 1 or 1½.

The work was designed under the direction of Mr. Isham Randolph, Chief Engineer, to whom we are indebted for plans, etc. The contract was awarded on April 13, 1898, to Hayes Bros., of Janesville, Wis., at $64,350, and the prices of the bids were published in the supplement of our issue of April 14, 1898. About 60% of the work is now completed.

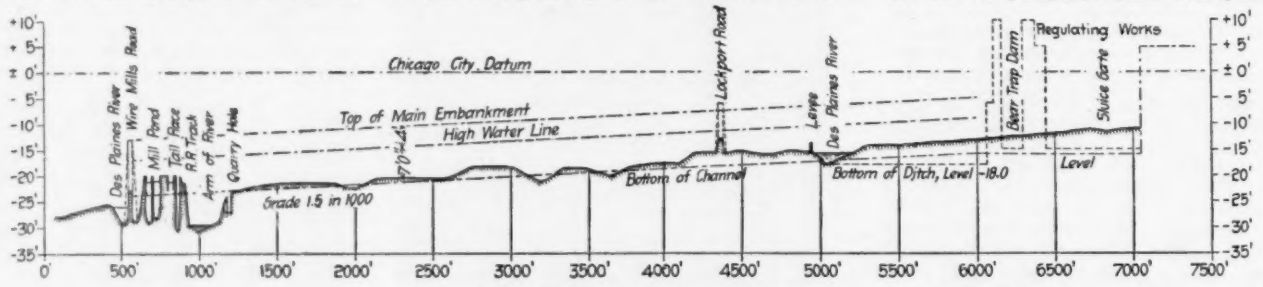


FIG. 2.—PROFILE OF TAIL RACE.

PUMPING ENGINES DRIVEN BY WATER POWER.

By Charles A. Hague, M. Am. Soc. M. E.*

The above caption is meant to cover that class of pumping machinery generally known as "power pumps," and the term is employed for the reason that there is considered to be no good or scientific sense in ignoring the fact that all pumps or pumping engines are operated by some sort of power application, whether it be human, steam, air, water, animal, electricity, or what not.

The type of pumping engine herein considered is that form which has its plungers operated against the water load, by means of a main shaft, cranks, crank-pins, connecting rods and cross-heads. Further, this article is confined to pumping engines wherein the pinion shaft is driven by gears from a turbine shaft, this being the only style practically in vogue in this country.

To begin with, it is assumed, from careful thought and observation, that 17 revolutions per minute of the main shaft for a quarter crank pumping engine, driven by means of gears, should be the maximum speed when the opening and shutting of the pump valves, and the shocks and jars incidental to the work are considered. It must be remembered that the work takes place between a solid crank-pin at one end of the machine, and a solid body of water at the other end. The above-mentioned speed can be exceeded of course, but the writer, if investing his own money, would be content to keep the speed down to at most 17 revolutions to insure reliability, long life and low rate of repairs, rather than to increase the revolutions and decrease the price of the machine at the expense of durability.

Even with water-works machinery operated by steam, the writer draws the line at 20 revolutions, all things considered; as the "duty" does not seem to be materially lowered by a low rate of revolution, possibly because the effectiveness of the steam jacket is proportionately higher at low speeds than at high.

The revolutions being taken then at 17 for the power pump, the plunger speed can only be varied in different pumps by changing the length of stroke; and with any certain length of stroke the quantity of water pumped varies as the area of the plunger. This brings up the advisability of some schedule of proportions, under which the manufacturer can arrange standard sizes, it being of course evident that it is equally for manufacturers' and purchasers' interests that standard sizes should be adopted. The writer would propose the following as embodying desirable proportions for pumping engines with quarter cranks, driven through the medium of gears and crank-pins:

Plunger diameter, ins.	Stroke, ins.	Travel, per min., ft.	Plunger diameter, ins.	Stroke, ins.	Travel, per min., ft.
8— 9 ..	16	40	24—25—26	48	136
10—11 ..	20	57	27—28—29	54	153
12—13—14	24	68	30—31—32	60	170
15—16—17	30	85	33—34—35	66	187
18—19—20	36	102	36—37—38	72	204
21—22—23	42	119			

At a speed of 17 revolutions it will be seen that the work of the pump valves will be precisely the same with the highest plunger travel per minute, 204 ft., as at the lowest. That is, the number of times of opening and shutting of the valves will be the same, and the velocity and duration of the rush of the water, through the valve seats and under the valves, will be precisely the same; provided, of course, that the aggregate of the areas of the openings of the valves is proportionately the same for all quantities of water, as it should be. For the operation of the suction valves this uniformity of revolutions is especially desirable. The filling of the pump chambers by the action of atmospheric pressure is practically the same regardless of the pressure of the discharge. If all of the pump valves are of the same size for all sizes of pumps, the system of manufacture is economized and simplified by putting in more or less valves to suit each particular size of pump, it being fairly conceivable that a size of valve could be determined upon which would not be too small for the largest pump, nor too large for the smallest pump.

The matter of the power required for driving this class of pump varies of course with the quan-

*39 Cortlandt St., New York city.

tity and pressure of the water, exactly as in the steam driven pumping engine, therefore the diameter and length of the crank-pins and cross-head pins, the load upon the main journals, the diameter of the main shaft at the middle of its length, the load upon the pinion shaft, journals, and diameter of the pinion shaft, together with numerous details, must be calculated for each power, just as the diameter of steam cylinders would be determined for a steam-driven machine.

The effect of the length of the stroke of the pump upon the proportions of the crank-pins is rather in favor of the longer stroke, as with a fixed rate of revolution the plungers will decrease in diameter for any certain quantity of water, the longer the stroke, and hence the gross load upon the crank-pin at any certain water pressure will be less. Therefore with a proper and fixed limit of load per square inch of longitudinal area of crank-pin, the pin will be smaller and work with less friction with the longer stroke. Of course commercial considerations come into play to prevent the increase in the length of stroke beyond a certain point.

The cross-head pin being supported at both ends can stand about 50% more load per square inch of longitudinal section than the crank-pin, although for the sake of the duplication of rod boxes and other parts which might be made alike, a manufacturer might prefer to make both ends of his rods alike, especially for the smaller sizes of machines.

Great strength and stiffness of the main shaft is extremely important in machines of this kind, as is also a low limit of load per square inch of longitudinal section of the main journals, and a limit of 116 lbs. per sq. in. of section is a safe pressure for long continued periods of work. Rankine's formula, using the constant 6.2832 (ratio between radius and circumference) and the constant deduced from the modulus of stress, of 225 for forged steel, and 180 for forged iron, represents good practice for main shafts of pumping engines driven by water power. With the area of cross-section of the main journal equal to 77% of that of the main shaft at its middle, and the journal given a length which will load it not to exceed 116 lbs. per sq. in. of longitudinal section, good hard steady work may be expected, with long life, low rate of repairs, and no stoppages. The pinion shaft should be developed by the same formula, the cube of its diameter varying with the main shaft directly as the revolutions, with the difference that the cube root in one case will be the diameter in the middle of the length, and in the other (the pinion shaft) the least diameter anywhere in the shaft. The load per sq. in. of longitudinal section of the pinion shaft journals should not exceed 100 lbs.

The writer's favorite ratio between main gear and pinion is 23 to 100, or as near this as the patterns will allow. He prefers a mortise tooth wheel for the main gear, with a pinion of strong cast iron, or steel, the teeth being accurately machined. There is no doubt that the practicable making and running of gears mark the limit of size in pumping engines of this class; and when the power required to pump the given quantity of water against the desired pressure or head calls for too large a gear, the units of quantity should be reduced and more pumps employed. There may be cases in which a main gear as large as 20 ft. in diameter with a 24-in. face might be used to advantage, but at present it seems to the writer that in most cases, if the required power calls for a gear larger than 16 ft. in diameter, and 24-in. face, it will be better to divide the quantity of water between more pumpng engines. The writer has formulated the following rule for main gear: For the pitch of the teeth, approximately 1-40th. of the pitch circle diameter; for the pitch circle diameter, not less than four times the stroke of the pump. The face of the teeth, for practical reasons in their making, should not exceed 24 ins., and for determining the face of the teeth, the maximum pressure based upon experience and observation is assumed for each inch of width of the face of the gear at the pitch circle. From this a constant is obtained in terms of foot pounds at the pitch circle, for a gear 1 ft. in diameter, 1-in. face, running at 17 revolutions per minute.

The work upon the plungers of the engine in foot pounds per minute, divided by the above constant, will give units of gear work, which divided by the diameter of the gear in feet will determine the face of the gear in inches. The pinion which will mesh with the gear will be amply safe for the transmission of the required power.

Concerning the cranks for such machinery, there are three kinds: The overhanging type, either of the disk pattern, of cast iron; or the arm style of forged steel; or the double or "U" crank, having a bearing at each side, this latter being a forging. The strength of the crank is referred to the plunger load in determining the diameter of the main hub, thickness of the main hub, diameter of the crank-pin hub, thickness of same, thickness of the crank web or arm, as the case may be.

In designing the main cross-head, the bearing of the cross-head pin at the sides is also derived from the plunger load, as that represents the stress imposed. The area in square inches of the cross-head shoe should be approximately the gross plunger load divided by the constant 165. The length of the shoe may be 1½ times the width.

The connecting rod for driving from the crank-pin to the cross-head must be considered also with refernce to the plunger load; its length should be not less than 2.75 times the stroke of the pump; 3 to 1 would make a trifle less friction at the cross-head shoe, but hardly enough to justify the extra cost of the machine, when such a slow motion and low number of reversals are employed. The diameter of the connecting rod at the neck, the diameter and also the smallest section at the head, or strap, are also referred to the plunger load.

The rod connecting the cross-head to the plunger is a very important member, taking as it does the direct shock of the water. Matters to be considered are: The tensile strain through the body of the plunger rod, length of solid metal in front of the key-way, thickness of the keys, depth of the keys, length of the taper entering the cross-head or plunger-head, pitch, size and character of thread, if threads and nuts are used in securing either one or both ends of the rod.

There are of course many other details of this machine to be considered, and when it is remembered that any material difference in quantity of water or pressure against which the water is to be pumped, calls for a difference in any of the proportions affecting the strength of the machine, it will be seen that economy in manufacture must be considered in deciding how far similar dimensions of parts may be used in machines for different powers. The writer holds, however, that engines of 50 HP. or more should invariably be designed to suit the particular service for which they are intended.

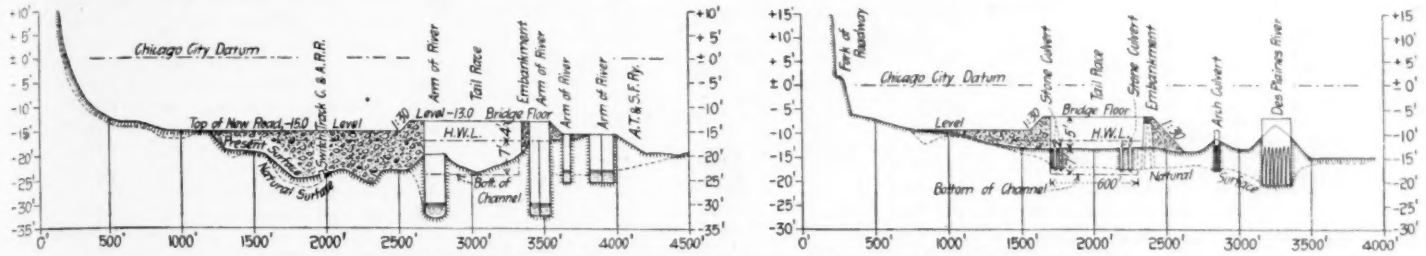


FIG. 3.—PROFILES OF ROAD CROSSING TAIL RACE AND DES PLAINES RIVER VALLEY.

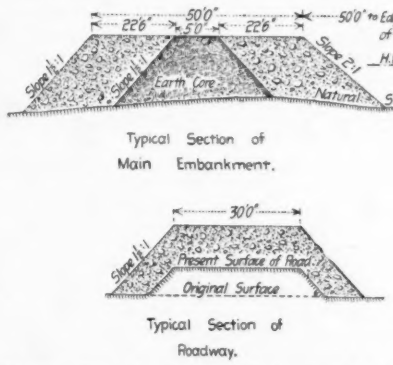


Fig. 4.—Cross-Sections of Embankment and Roadways.

FIREBOX WATER TUBES are used on some new eight-wheel passenger engines of the London & Southwestern Ry. (England). There are 82 tubes, 2¾ ins. diameter, crossing the firebox from side to side, a box-like casing on each side of the firebox forming the water chamber. Some of the engines have four cylinders 15×26 ins., while others have two cylinders 18½×26 ins. All have driving wheels 6 ft. 7 ins. diameter, with a driving wheelbase of 11 ft., this exceptional length being made necessary by the size of the firebox. The engines were designed by the Locomotive Superintendent, Mr. D. Drummond, and were built by Dubs & Co., of Glasgow.

THE EXISTING RAILWAYS OF SWITZERLAND are classified as follows, according to a report recently made by the United States Consul at Berne, Switzerland:

Description.	No. of lines.	Aggregate length, miles.
Main steam trunk lines	28	1,943.0
Narrow-gage lines	24	389.6
Cogwheel lines	10	56.5
Cable lines	20	11.8
Street-car lines	26	88.9
Total	108	2,489.8

THE RAILWAYS OF CAPE COLONY aggregated 2,662 miles at the end of 1898, practically all of which belong to the system of the Cape Government Railway. Only 33 miles are double track. The new 70-lb. rails are found to be cutting the ties very badly, and 100-lb. rails are to be used instead. The 85-lb. rails imported from the United States are said by the engineer to make the best track with T rails that he has ever seen. The metal ties are giving out on account of their age, but it is not likely that new ones will be laid. Experiments are to be made with the zinc-chloride preservative treatment for native and imported timbers, but the former afford only a limited supply of ties. The cultivation of certain grades of pines is proposed. The automatic vacuum brake is used on all freight and passenger rolling stock, and long freight cars mounted on Fox steel trucks are being introduced. The Superintendent of Motive Power has recommended certain modifications in the locomotives to increase the size of the firebox and boiler and so get better performance. The Baldwin engines are reported as giving satisfactory service. Various extensions are to be made, and some of these will have a gage of only 2 ft. instead of the standard gage of 3 ft. 6 ins. On the Beira Ry. the original 2-ft. gage has been widened to 3 ft. 6 ins. on account of the unsatisfactory capacity of the locomotives, but it is thought that a new type of locomotive for the new lines of 2-ft. gage will give better results. New signal and interlocking plant is being introduced, including the electric train-staff and train-tablet apparatus, and an interlocking plant operated by hydraulic power. Mr. C. B. Elliott is General Manager; Mr. John Brown, Engineer in Chief, and Mr. H. Beatty, Chief Locomotive Superintendent.

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CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, J. J. SWANN, } ASSOCIATE EDITORS.

A. B. GILBERT, - - - - - - - ASSISTANT MANAGER.

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The city of Columbus, O., has been trying hard to make itself a "convention city." Doubtless it has many motives for this. Some of these motives, as indicated by events at and since the recent convention of the American Water-Works Association in that city, show a most commendable thirst for knowledge. Thus, during the convention some of the city officials induced a number of engineers to visit the site for a water storage dam, over which, and the design of the structure, there had been much controversy. The professional opinions of these gentlemen was sought by the city officials (none of whom were engineers) in a manner which showed a thirst for knowledge and an aptitude for questioning that would have done credit to Socrates. The controverted points seem to have been settled in this delightfully friendly way, for the plans have since been conditionally approved by the State Board of Health, as noted elsewhere in this issue, and that without any subsequent engineering consultation or fees, so far as we have heard.

Another point on which light was sought was whether a city could afford to supply metered water at a flat rate of 6 cts. per 1,000 gallons, without a minimum meter rate, and with some consumers using from 1,500 to 8,000 gallons of water during six months. The joint wisdom of the convention was appealed to in this case, resulting in such a flood of light that the city officials have since decided to raise the meter charges 2 cts. and establish a minimum charge.

We regret to see that although the evils of polluted water were emphasized in the convention, plans for the new supply were nevertheless submitted to the State Board of Health in such shape that their approval was conditioned on the adoption of purification to avert the dangers of sewage pollution. But in such a brief period as the convention afforded, it is not surprising that many crumbs and a few large morsels of knowledge escaped the officials in question. It is only fair to say that the present administration at Columbus had just come into office when the convention assembled there and that the unsatisfactory condition of affairs was largely due to the previous administration. The officials intended to take no undue advantage of their guests, although the appearances were to the contrary, and we are sure that in the long run no one who responded to the requests for voluntary information will be the losers thereby.

The suit brought by the city of Paterson, N. J., to restrain Summit from discharging the effluent from its sewage filter beds into the Passaic River many miles above the intake of the Paterson water supply has given rise to a variety of comment by the New Jersey press. Only a few months ago, riparian owners secured an injunction against any increase in the amount of sewage discharged by Paterson into the Passaic, pending a decision involving the whole sewage flow of the city. Until within a very few years Jersey City, and a little earlier Newark also, was dependent on the Passaic for its water supply, but Paterson then saw no harm in discharging its sewage into the river above the water intakes of the two lower cities. The adverse decision against Paterson, just mentioned, however, and occasional outbursts of typhoid fever have led it to regard water pollution in a new light. Some people think that Paterson is more zealous than wise in its crusade against Summit, which is far above it, has a comparatively small volume of sewage, and has always maintained a plant to purify that; besides which, the dilution of the effluent before it reaches the Paterson intake is very great. When so few towns make any pretence of purifying their sewage, it seems hard for one of the pioneers in that field to be brought into the courts for discharging its effluent into a comparatively large volume of water. We fear that Summit has laid itself open to attack in one respect, which is that it has been strongly inclined to content itself with providing a purification plant, leaving the plant to run itself, with little attention save that given by ordinary laborers. If this is the case, one remedy is simply better men and more money.

By what may not be so much of a coincidence as appears on the surface this suit against Summit comes just as a joint outlet sewer is being undertaken by a number of neighboring towns. Prospects of law suits and a certainty that its filter beds must receive more attention and cost more in the future than in the past will be powerful arguments on the tongues of those who advise that Summit join South and West Orange, Millburn, Vailsburg and Newark in the construction of an outlet sewer to tide-water.

East Orange abandoned its disposal works some time ago and joined Newark in building a sewer to tide-water. If Summit follows suit, it will be no more of an argument against sewage purification works than was the action of East Orange. Each municipality will have changed because joint disposal to tide-water promised to be more economical than the maintenance of small purification plants. In fact, it would not be surprising if the sewage of both Summit and East Orange were treated later on at some immense disposal plant or plants. For years all the sewage of the lower Passaic valley has been tending to the river, and to Newark Bay. A joint trunk sewer for Newark, Passaic, Paterson and a score or two of smaller places has been discussed for years, as these columns bear witness. If dilution proves insufficient, as a matter of fact or sentiment, some treatment will be necessary before the sewage thus brought together from a population of several hundred thousand can be discharged into the shallow waters of Newark Bay. Whatever the outcome of the Summit case, and all the other agitation, it cannot but be wholesome to have public attention called to the importance of keeping our inland waters pure, whether used for drinking purposes or not; but a thousandfold more important when so used.

We regret to have to record that a representative of a filter company has again sought to further his own commercial interests by urging that engineers are governed in their work by commercial rather than professional motives. In the present instance as in a former one, which we noted some time ago, a city secured engineering advice regarding water purification, and after it appeared that slow sand, rather than mechanical filtration would be adopted, an official of one of the mechanical filter companies appeared on the scene and urged that nothing else could be expected, since an engineer was sure to recommend a plan requiring the continuation of his services rather than one where his employment would cease with the presentation of his report. There was an attempt to avoid the appearance of a personal attack on the engineer by saying that it was only "human nature" for the latter to recommend that course which was most for his personal interest; but such a remark by no means palliates the offense. A professional adviser is bound in honor to give to his client honest and sound advice, and an engineer would have no more right to consult his own interest in giving advice than would a lawyer or a doctor. We are glad to say that such attacks by salesmen on the reputation of engineers are comparatively rare; considering the frequency with which their advice comes in conflict. In most cases the salesmen and the firms which they represent, are, we are glad to believe, too honorable to adopt such tactics; and when this is not the case are generally too politic to do so.

THE TEXAS RAILWAY COMMISSION AND RAILWAY RATE DISCRIMINATIONS.

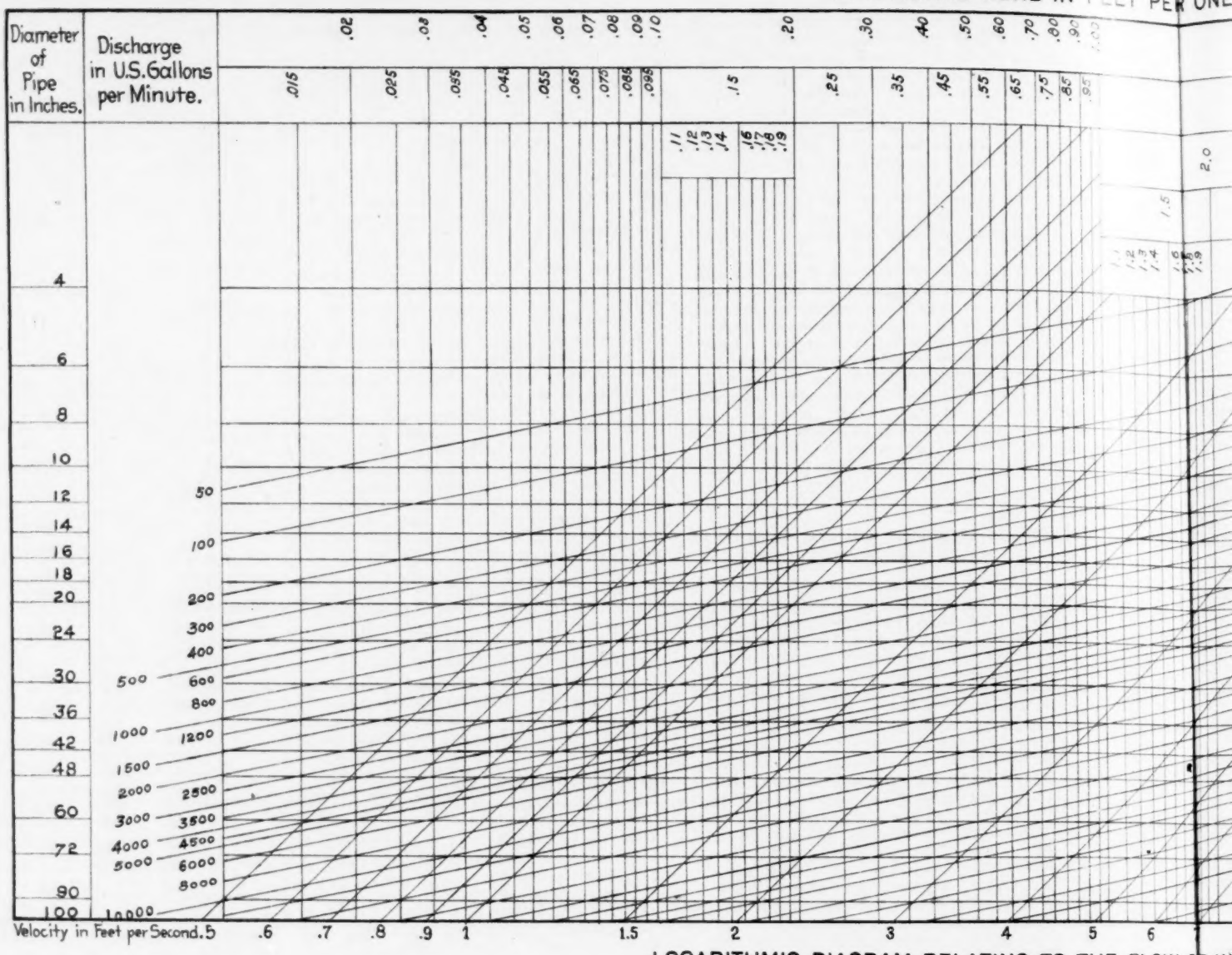
The state railway commission of Texas has recently turned its attention toward the abuses prevalent among the railways of that state in granting free passes for passenger transportation and rebates on freight rates, and it has obtained some very interesting information. It is pretty well known in a general way, of course, that the granting of passes and of rebates continues, notwithstanding legislation prohibiting it; but few persons are aware of the extent to which such discriminations are now practiced. The investigations of the Texas railway commission throw considerable light on these matters, and will repay careful study.

Taking up the matter of passes first, it may be noted that the commission's figures are based upon official reports from 29 Texas railways operating 8,673 miles of line, all within the state boundaries, or nearly 91 per cent. of the total railway mileage of the state. These 29 railways gave out altogether during the year ending June 30, 1898, 177,678 free passes. Of this total number, 4,730 were time passes, and 127,766 were passes good for a single trip only. The recipients of these passes and the number of passes granted to them are classified as follows: In exchange, to officers, agents and employees of other roads, including also express and telegraph companies, 45,909; to employees of the roads reporting, including their families, 103,421; and to editors, public officials and other persons, 24,587.

These are merely the bare figures, but their magnitude will, we think, be a surprise to many. Unfortunately the commission was unable to obtain information which would show the exact amount of revenue lost to the railways by the allowance of these passes, but it is plain that it must have amounted to a considerable sum, and the commission argues with much sound reason that this sum, or some portion of it at least, should in justice to the public be saved to the railways. Basing its demands upon these reasons, the commission urges further that justice and fairness and the public interests require that the practice of issuing free passes should be prohibited by law, with such exceptions only as may be deemed justifiable.

There are apparently many sound reasons why the granting of free passenger transportation should be restricted by legislation. If the income of the railways is to be preserved it is evident that they must make up the revenue lost in giving passes to one part of the people by charging the others a higher rate for transportation than they would have to be charged if everyone paid alike. This is an unjust tax on the people who pay the full price for their transportation. As matters really stand, the discrimination is more reprehensible than it first appears, because free passes

FRICTIONAL HEAD IN FEET PER ONE



LOGARITHMIC DIAGRAM RELATING TO THE FLOW OF W

Prepared by Geo. T. Prince, M. Am. Soc. C. E.,

EXPLANATION.—The vertical lines indicate frictional head in feet per 1,000 ft. of pipe. The horizontal lines indicate the internal diameter of pipe in in per second.

EXAMPLES.—A 10-in. pipe is carrying 500 gallons per minute; find the frictional head per 1,000 ft. Follow along the inclined line marked 500, to its int loss per 1,000 ft. as 5.5 ft., what size of pipe will be required to carry 2,000 gallons per minute? Follow down the vertical line marked 5.5 to its int second.

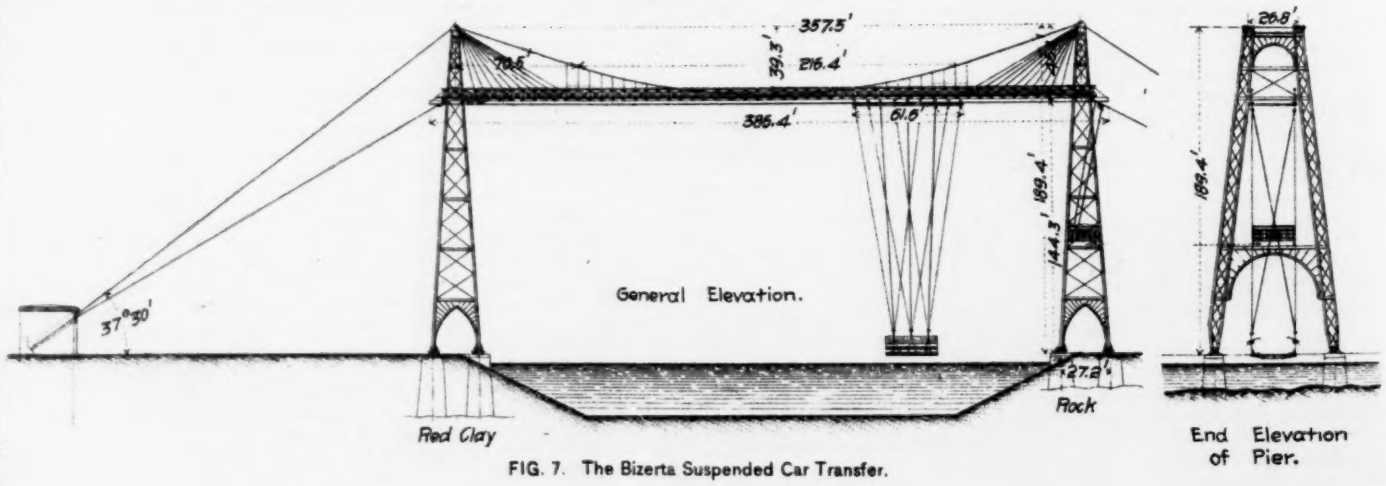
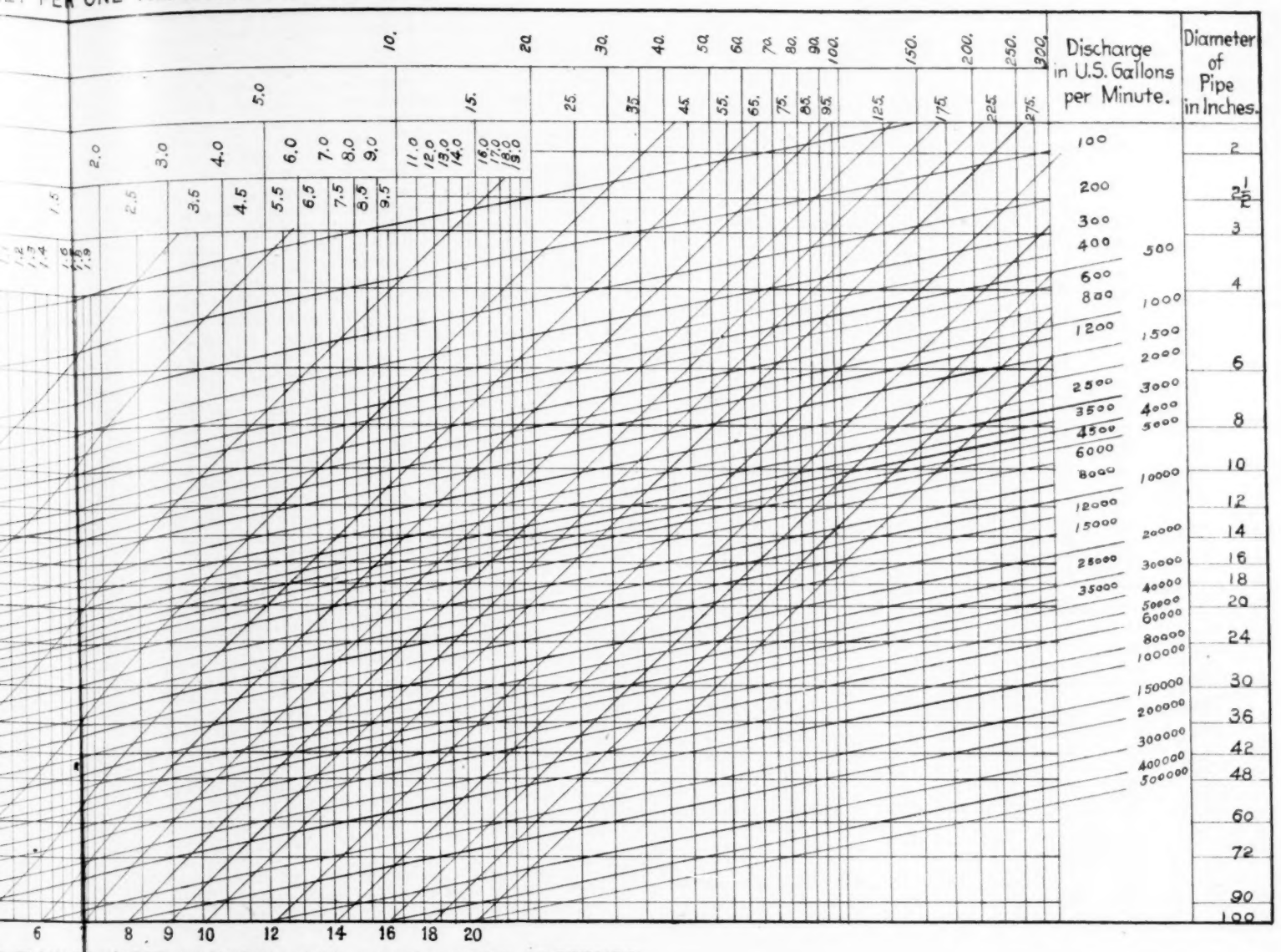


FIG. 7. The Bizerta Suspended Car Transfer.

SOME EXAMPLES OF RECENT FRENCH BRIDGE CONSTRUCTION.

ET PER ONE THOUSAND FEET OF PIPE.



E FLOW OF WATER IN CLEAN IRON PIPES UNDER PRESSURE.

Am. Soc. C. E., after the design of A. Van Muyden, C. E.

ameter of pipe in inches. The lines less inclined to the horizontal indicate gallons of water discharged per minute. The oblique lines indicate velocity of flow in feet

arked 500, to its intersection with the horizontal line marked 10, and then up to the top of diagram, where desired result, 1.7, is obtained. Assume the frictional narked 5.5 to its intersection with the inclined line marked 2,000, and we find a 14-in. pipe would be required, and the velocity of flow would be about 4.2 ft. per

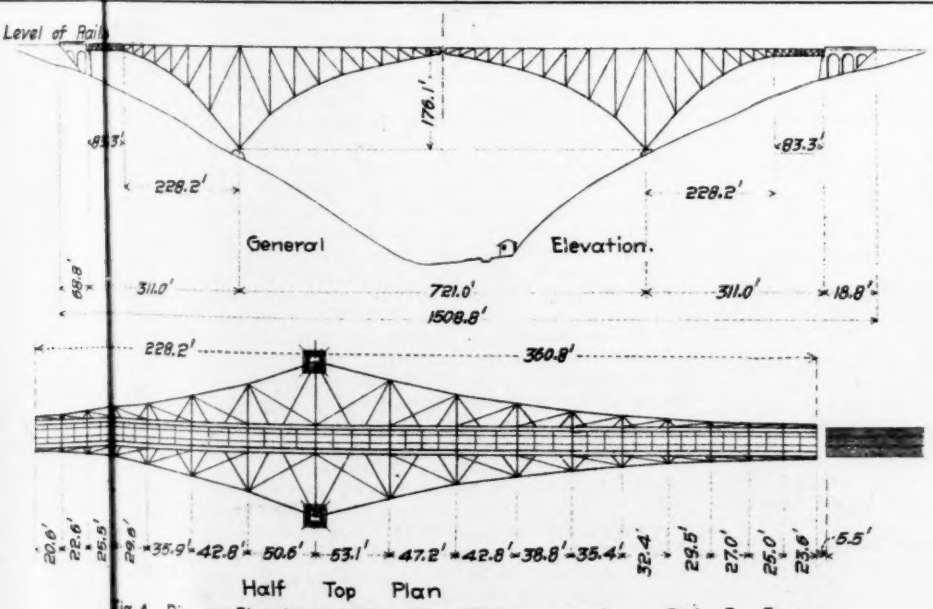


Fig. 4. Diagram Elevation and Plan of Viaur Viaduct on the Carmau-Rodez Ry., France.

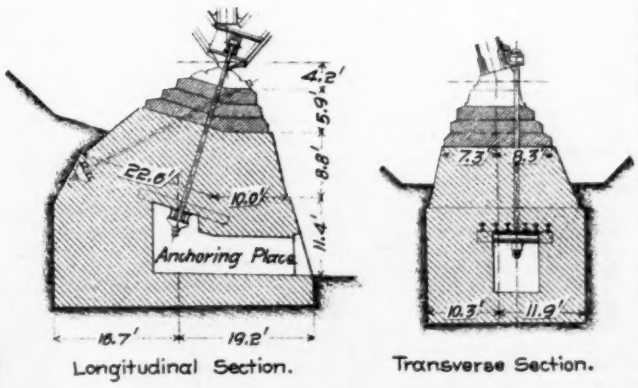


Fig. 5. Abutments for 722 ft. Arched Center Span Viaur Viaduct, France.

CHAS. HART, LITH., 58 VESEY ST., N. Y.

are usually given to those who are well able to pay for their transportation.

Excepting such passes as are given to employees, and railway officials, the bulk of this free transportation is given to persons holding some official position, for the purpose, it is reasonable to presume, of influencing their official conduct, or else to merchants, with the evident design of determining their choice in the selection of the lines by which they shall ship their merchandise. In the latter case it is evident that unless all shippers are treated alike in this bestowal of favors those not receiving passes are subjected to a heavier expense in transporting their merchandise, which is about equal to the sum which they pay in passenger fares in conducting their business. They, with every other traveler, also have to pay higher rates to make up for the revenue lost by the railways in granting free transportation to certain favored persons. The fact that this is discrimination between shippers is plain.

The ulterior motive for this discrimination is also plain, whether it consists in influencing the patronage of large shippers or in bidding for the good-will and favors of the men in public office. In the latter case, indeed, the discrimination becomes, in addition, a species of bribery. This is made manifest by the fact that passes are not given to such persons except while they hold official positions, and can influence legislation or secure desired privileges or immunities from the action of the laws.

Turning now to the commission's investigations of the matter of granting rebates on freight rates, we find also a number of suggestive figures. The commission states that the investigation covered the operations of only a few companies for only a limited period, it being undertaken more to show that such violations of the law really existed than to ferret out every instance of such practice Partial as the investigation was, however, it resulted in the discovery of 135 cases in which rebates had been granted, and for which the companies were fined the sum of $500 each, or $67,500 altogether. In each instance the company plead guilty to the charges and paid the fine imposed without litigation. It is proper to add that many more instances of violation were found than were settled for, upon which the commission suspended punishment until the event of further violations of the law.

These facts are very significant. They show that the railway companies of the state of Texas have by their voluntary action, and by violations of the state laws, reduced their resources considerably below what they would have earned had they adhered to and collected the freight rates prescribed by the commission. When we consider also that all of these violations were committed by five railway companies, it is further evident, although these railways possess a good part of the railway mileage of the state, that this represents only a part of the revenue voluntarily forfeited by the railways of a single state in granting secret rebates on the legal tariffs for freight transportation. To secure the total amount of revenue lost by these rate discriminations we must add to the sum represented by these rebates, the amount given away in the form of free passes to passengers, who would otherwise have paid their fare. This total amount, as we have already said, must be very large; but, whatever it may be, the fact that the railway companies voluntarily give it up, indicates that either the regular rates which they charge for transporting persons and merchandise are higher than they should be, and would be if all paid alike; or else the holders of railway stock and bonds are receiving less revenue than they are entitled to.

Apparently the railway companies cannot be depended upon to correct the abuses which we are considering, or else they would have done so long ago. This being the case, the contention of the Texas commission, that the public must step in with its lawmaking powers and put a stop to them by legislation, has some foundation. The difficulty exists, however, in making such legislation effective. It will be easy enough to draft prohibitory laws against granting free passes and rebates; in fact there are plenty of such laws now on our statute books; but it will not prove to be so easy to make the railways obey these laws. The experience of the Texas commission in ferreting out the evidence of rebates upon which it based the prosecutions which have been noted is pretty good evidence of this fact. The commission found after many trials that even public examinations of railway officials under oath were not sufficient to obtain facts upon which definite action could be based. Attempts made to get the same facts from shippers were also failures, and the commission was finally compelled to employ experts to audit the books of the railway companies and secure evidence in any other possible manner before it could secure the data which would justify legal action being taken.

It seems apparent, therefore, that any laws which are passed to restrict the granting of free passes and rebates to be most effective must also provide the machinery for efficient work in searching out violations of these provisions. This is not a very difficult matter, perhaps, but it means heavier appropriations for carrying out the work of state railway commissions and places a power in the hands of these commissions which may easily be used for evil. These are, perhaps, conditions which can also be provided for successfully by our lawmakers. A great danger, however, lies in the possibility that they may be neglected or only partially understood, and that forces may be created which in the hands of incompetent or unscrupulous men will be used for other ends than those they are designated to further.

We have not attempted to do more in what has been said than to outline the work being done by the Texas railway commission in an important field of reform, and to suggest the possibilities for this same sort of work elsewhere. It is made plain, we think, from what has been said, that the problem is not one which can be settled offhand, but requires careful study and impartial investigation.

It is a noteworthy fact that in the public discussions of the railway problem, no voice has been raised in defence of the practice of discrimination. Even that most vigorous fighter, Mr. Milton H. Smith, President of the Louisville & Nashville R. R., who has become prominent as an opponent of the grant of additional powers to the Interstate Commerce Commission, admits that discrimination is an injustice to the railway owners, to those who pay full rates, and to the public generally.

If, now, the practice of Texas railways in this matter is a fair example of railway practice the country over, other State commissions may well follow the example of the Texas commission. To allow the practice of discrimination and secret rebates to continue is to add another to the forces which are building up the large concerns at the expense of the small ones.

LETTERS TO THE EDITOR.

Health Records of Companies in the Spanish War.

Sir: Without detracting in any way from the record of the late Capt. Alfred O. Hunt, I think a correction in your editorial note of June 22 should be made. The statement is: "He is said to have been the only commissioned officer who went to Cuba or Porto Rico in the late war and brought back to the United States every man of his command."

The correction to this statement is, that in the 2d Battalion, 3d U. S. Vol. Engrs., three companies did not lose a single man by death, either in this country or in Cuba. Those companies were Co. "E," Capt. Chas. H. Smith, of Rome, Ga.; Co. "H," Capt. W. Bailey Thomas, of Augusta, Ga., and Co. "G," Capt. Lyle F. Bellinger, of Atlanta, Ga.

Moreover, in this whole 2d Battalion there was not the loss of a single man by death from the date of muster-in until the Battalion left Cienfuegos, Cuba. One man from Co. "F," who was transferred to our regiment, died of appendicitis the day after we left Cuba. This Battalion was commanded by Major Henry C. Davis, now instructor at West Point, from muster-in until Aug. 24, 1898; by Capt. Lyle F. Bellinger, from Aug. 25 to Oct. 31, 1898; by Major John L. Van Ornum, from Nov. 1, 1898, to May 17, 1899. There were also other companies of our regiment who lost no men, I think, but I do not know them now. Very resp'y.

Lyle F. Bellinger.

(We made the statement concerning Capt. Hunt's record in the matter stated as it was made to us by a personal friend of his, and cannot vouch for its accuracy. We believe, however, that it referred to the troops which went to Cuba and Porto Rico while hostilities were still in progress. The engineer regiments all reached the islands after the signing of the peace protocol.—Ed.)

The Strength of Wooden Beams.

Sir: On page 499 of "Trautwine's Engineers' Pocket-Book" is given a table of safe quiescent loads for rectangular beams one inch broad and loaded at the center. In Kent's Mechanical Engineers' Pocket-Book, page 1023, is a table giving the same information. I refer to Table I. calculated by C. J. H. Woodbury.

Each of these authors claims his table to be for a factor of safety of six, yet the loads given by Mr. Woodbury are from one-fourth to one-eighth of those given by Trautwine, though Trautwine's table was computed for white pine and spruce and Woodbury's for Southern pine.

I have used Trautwine's table for proportioning beams for coal bins, light railroads, etc., and have never heard of a single failure, hence I do not see the use of so material a reduction of the load as Mr. Woodbury's table indicates.

Below I have calculated the load on two beams by the formula $M = \frac{S\,I}{C}$ and compared them with the loads given in the tables referred to above. S was taken at 1,200:

	Beams			
	1 × 6-in. × 6 ft. long.		6 × 10-in. × 10 ft. long.	
	Concentrated center load, lbs.	Uniform load, lbs.	Concentrated center load, lbs.	Uniform load, lbs.
By formula $M = \frac{S\,I}{C}$	400	800	4,000	8,000
By Trautwine	450	900	4,500	9,000
By Woodbury	120	240	720	1,440

I should like to hear from other members of the profession on this subject.

Yours very truly, H. T. H.

Lytle, Georgia, June 11, 1899.

Random Notes Abroad.

II.

Sir: The traveler on an Italian railway, in addition to struggling for a seat in a compartment, must find the proper window in the "booking" office to present the circular tourist ticket for the "visé"—that is, the traveler must inform the office where he proposes to disembark, and the ticket must be duly stamped for that place, otherwise you cannot pass the wicket to the train platform. This window is not opened until a brief period before the train leaves, and the people with local tickets, which do not require stamping, pass in to fill the compartments.

The traveler who knows the ropes and does not wish to lose his chance of a seat gives his hotel porter a small sum to invest "where it will do the most good." A uniformed official takes the ticket and the tip, disappears for a moment, reappears with the ticket properly stamped and the traveler passes through the wicket ahead of the long line of waiting passengers. At Milan we noted some progress. The whole business of registering luggage and visèing tickets is done at the principal hotels, to the relief of the tourist and the tourist's pocketbook.

Going from Italy into Switzerland, the improvement in railway standards is noticeable; the carriages are better and cleaner; the trains make faster time; there is no examination of tickets except to register one's luggage; the conductor comes through the corridor train, as in the United States. There is no free luggage in Switzerland, but the Swiss railway officials are so liberal that the thrifty travelers greatly overdo the hand-luggage business, and the compartments are stuffed with big valises. In Germany first-class baggage goes free, the second class has 56 lbs. free, and the lower the class the less free baggage is allowed. There are four classes of passenger coaches in Germany. In the fourth class there are seats around the sides and ends of the compartment except at the doors. No free baggage is allowed, and the German women with large baskets on their backs stand in the center or, if there is room, sit on the floor. These coaches are attached to the slowest trains, and are used for local traffic only. The German second-class coaches are more comfortable than the American first-class; the upholstery is as good, the seats are roomy, and by the compartment system the head rests against the back of the seat, and sleep may be enjoyed in comfort. Moreover, the trains are on the corridor system, toilet conveniences are always accessible, and the coaches are clean.

The International Sleeping Car Co. runs "Wagons-Lits" over the principal Continental railway lines. They are "trains de luxe" and are expensive luxuries. I made inquiry at the office in London about the sleeping-car fare from Paris to Marseilles. It was 55 francs, or $11 for a ride of 10 hours. This amount, however, did not absolutely secure the berth, but gave me the privilege to claim or occupy one if it was not already appropriated. It was necessary also to deposit the money a week or ten days in advance, giving notice at the same time as to the night when I wanted the accommodation. Under these rather

onerous conditions, like the majority of tourists, I preferred to stop over in Paris and go by day express. It is also quite the custom for travelers to stop off at Lyons, or at Avignon, go to a hotel, and resume the journey next morning. We left Paris at 9.40 a. m. and arrived in Marseilles at 11 p. m., one hour late; there were very few stops made, as there is no local travel on express trains.

A dining-car was coupled on at about 6 p. m. A man came around and handed a numbered ticket to intending diners. At a specified hour the lucky first numbers passed in; an ordinary table d'hote dinner was thrown at us and the dishes were snatched away as speedily as possible.

After one such experience in a Continental dining-car, one lays in a few oranges before going aboard the train, and supplements them with the very good sandwiches that are offered at most of the principal stations en route. For the indifferent fare given the charge is five francs, not including wine, which is cheap and poor, also. The attendance is as unceremonious as at the lunch counter of an American country fair.

There is sometimes a feeling of uncertainty in the minds of American tourists—especially on their first trip—as to the "class" of compartment which they will patronize in foreign railway travel. I have in the past few months used each class, including the train de luxe on a German railway. First-class railway fares are much more expensive every where in Europe than in America. Third-class compartments on nearly all English railways are quite as comfortable and clean as the ordinary first-class cars on American lines, and they are the class in most general use. An objectionable person in an English carriage is even more rarely met with than in American cars. On the Continent third-class carriages are never attached to fast trains; they are for local traffic, and are rarely, and with reason, used by tourists. Second-class coaches everywhere in Europe can be safely used; we had a "first-class" circular ticket from London to Naples and back to Lucerne, and it was a frequent cause of regret that we were separated from pleasant traveling acquaintances, American and English, by their taking "second-class" carriages. The special merit of "first-class" is that it is used by so few ordinary tourists that, except on the overcrowded French lines, the occupants usually have extra room; on night trains this is especially serviceable, as it is almost certain that a party of two or three at most can secure an entire compartment, have it locked, and with drawn curtains and shaded lamp be more comfortably equipped for sleeping than in any Pullman sleeper. To the average tourist, desiring to combine comfort with economy, I recommend "third-class" in England and "second-class" on the Continent, always paying the extra charge for "first-class" when traveling by water, however. Circular tickets from one of the tourist agencies are practically a necessity. It is a sheer waste of money to patronize the so-called "sleeping cars," as one soon learns from the evidence of travelers. At all large Continental stations very nice luncheons are for sale, and are more satisfactory than the "dining-car" fare. The compartments are warmed by iron "heaters" filled with hot water, and changed en route, so that a superabundance of rugs is quite unnecessary; toilet conveniences are on all trains, so that the fears of old times experience are quite dissipated. The compartment system tends to sociability and an interchange of courtesies, and really disagreeable people are exceptional. Railway trains are run carefully and on time, and are under constant inspection in stations. We always found the officials very courteous.

One of the "stock" subjects for grumbling travelers is the customs examinations at the frontiers of the several Continental states. On this tour, as on three previous ones, my experience was entirely satisfactory. At Liverpool I had my small stock of cigars (about 20) on top of the contents of my valise; only one package was opened, and immediately passed. At Dieppe, France, nothing was opened, my simple declaration at Paris was sufficient to secure the customs mark of approval; at Ventimiglia, Italy, which is the dread of tourists, nothing would exceed the politeness of the examining officials; our trunk was opened and immediately closed, its contents untouched, and the only gratuity passed was to the porter who handled it. We found the same courtesy in Germany, Switzerland and Belgium, and on our return to London, and we never saw a chance where a gratuity was expected or possible. In fact, it was a risky thing to attempt it. In France the authorities are over-rigid on the subject of matches; the tourist is liable to a fine of one franc each if more than six sulphur matches of foreign make are found on him; throwing them away does not help. Six cigarettes or cigars are allowed in Italy, but it is better not to carry any. The temptation is great, however, as cigars in Italy are very expensive—one to three francs each—except the horrible things consumed by the natives, which can be bought for a few centimes each. Besides the government customs barriers, in France and Italy there is the "octroi" in every city and town. At every entering highway an officer looks into the cab, omnibus, street car or country cart for "comestibles," on which, if found, a duty is levied. On a street car in Genoa, coming from the celebrated cemetery "Campo Santo," I noticed an Italian woman pay "octroi" on three ordinary one pound cans of crackers, and a man in the same car paid on some small packages which he had with him. Arriving on late trains, we always handed the keys of our registered luggage to the hotel porter as we got into the omnibus. This was for examination for "octroi," but we never knew of a trunk being opened. If you have a few oranges along, however, it is advisable to dispose of them before coming to an "octroi" gate.

A tourist circular ticket to Southern Europe over the Paris, Lyons & Mediterranean Ry., with return over the same, is issued at 45% discount from the first-class rate. As we were not returning by this route, we did not get the rebate. On the Italian ticket, 35% rebate was allowed, but the tourist must use up the ticket in 60 days or forfeit the unused portion. To gain time, we paid for local tickets from Ventimiglia to San Rémo, where we spent one week, and our use of the circular ticket dated from our departure from San Rémo

For tourists with plenty of time at their disposal, the 60-day Italian circular ticket becomes a positive nuisance; the fascinations of Rome, Naples, Capri, Florence and Venice easily consume sixty days. There are a good many days of travel in trains and there ought to be days given up to absolute rest, as sight-seeing is very fatiguing work. The anxiety to get the full benefit of the rebate on the ticket urges one to either overwork or shorten the stay in some interesting locality. A celebrated writer has said that a ten years' study of Rome will give one a "superficial" knowledge of the city and its wonderful history; we met one man who was there on his 27th visit, and many others who had been going there for many years. We realized that at the end of three weeks of fairly energetic work, with the use of the best service of cabs, omnibuses and tramcars, with attendance on lectures at the Colosseum, and amid the ruins of the Roman Forum and the Palaces of the Caesars, with books, guides and acquaintances, we were barely at the commencement of an acquaintance with the Eternal City.

In Italy the high charge for carriage of baggage at once impresses uncomfortably the economical tourist. At Nice we lightened our load by sending the heaviest rugs, wraps and winter clothing back to London; a small box cost twelve francs by ordinary freight—"slow vitesse"—and it took over three weeks of time in transportation. At Rome, to save cost of transportation, we packed absolutely necessary clothing into hand luggage, then sent the rest on to Venice to await our coming.

From Rome to Venice takes two weeks of time. By the time the tourist reaches Naples he has reduced his impedimenta to the minimum, and he finds that most of his fellow travelers have done likewise. A lady has discovered that she can get along with her one most inexpensive bonnet, and unless she proposes to remain for some time, her entire wardrobe is probably more limited than she ever supposed she would dare venture away from home with. By the time she has "done" Florence on her return from Naples, and has overtaken her trunks at Venice, she has learned a valuable lesson in traveling. A superabundant wardrobe in Italy is a superlative expense and nuisance, except for the ultra-fashionable.

The Paris, Lyons & Mediterranean Ry. is the chief trunk line of France; it is the direct route to Marseilles, where travelers to Algiers, Tunis and other north African ports embark; the great steamers of the P. & O. line to Egypt and India call here for the overland passengers from England; the bulk of the tourist-travel to the French Riviera reaches Cannes and Nice and Monte Carlo by the P., L. & M. route, and the travel to Rome via the Mont Cenis tunnel and Turin passes over the same line to Geneva.

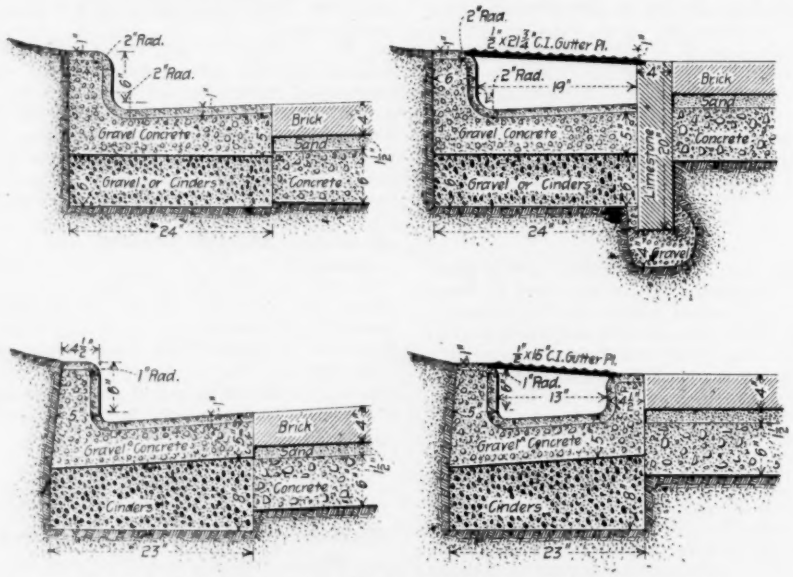
The Paris, Lyons & Mediterranean Railway Company is the great power politically of central France, and by use of this power it has arrested much needed improvement in railway service to southern Europe. From Marseilles the line runs past Toulon, and close by the Mediterranean to its terminus at Ventimiglia. It is here exposed to hostile attack from the sea, and to remedy this weakness the French government has for many years had a projected line under construction, branching from Avignon or thereabouts and running through the mountainous and picturesque region of the Maritime Alps. Once completed, this would be a favorable route for tourists to the Riviera, but the power of the P., L. & M. Co. is such that the years pass by and very little progress is made. There is a line, however, through these mountains by which the traveler reaches Grasse, and Cagnes, thence to Cannes or Nice. I went over the division to Grasse from Nice; it is a narrow gage line (1 meter), but with a third rail laid to the same gage as the P., L. & M.., for purely military use. The difficult and excellent engineering of this marvellously picturesque mountain railway must be seen to be appreciated. Any attempt of mine to describe it from one day's outing upon it when the eye was endeavoring, not only to take in the engineering features, but the magnificent landscapes as well, would be wholly inadequate.

In this region one sees orchards of oranges and lemons in full bearing from blossom to ripe fruit. The train also runs through endless flower farms, producing the raw material for the large perfumery factories, which are the special industry of the mountain city of Grasse, which is celebrated also as one of the favorite winter residences of Queen Victoria, who, indeed, first brought it into conspicuous notice.

G. H. F.

THE USE OF CONCRETE CURBS AND GUTTERS.

The use of a concrete combination curb and gutter, built in place, is now becoming very general in the smaller cities and in suburban residence towns. According to a paper presented at the latest annual meeting of the Illinois Society of Engineers and Surveyors, by Mr. W. H. Tarrant, City Engineer of Champaign, Ill., the cities of Champaign and Urbana put in 15,000 lin. ft. of this construction during 1898.



SECTIONS OF CONCRETE CURBS AND GUTTERS AT CHAMPAIGN, ILL.
W. H. Tarrant, City Engineer.

The curb is 7 ins. high and 5 ins. thick, with top and gutter edges of 2 ins. radius. The gutter flag is 24 ins. wide from the back of the curb, and 6 ins. thick. The concrete is laid on a foundation of 6 ins. of gravel or cinders, flooded with water and rammed with 60-lb. rammers. It is composed of 1 part cement and 5 parts gravel, and has a 1-in. finishing coat of 1 part Portland cement and 1 part sand. It is built in sections 7 ft. long, and the finished work is covered with canvas, which is kept wet for 24 hours.

At Champaign, the concrete was made with fine sharp sand and gravel, with no stones larger than 2 ins. American Portland cement was used, of such fineness that 94 to 84% passed a No. 100 sieve. The strength of the cement was from 200 to 300 lbs. in 24 hours, 500 to 700 lbs. in 7 days, and 600 to 1,000 lbs. in 28 days. The contract

price was 39 cts. per lin. ft., including excavation. This work was done under the direction of Mr. Tarrant.

At Urbana, a German Portland cement was used, which was of lower tensile strength, but was more uniform in quality than that used at Champaign. The contract price was 46 cts. per cu. yd., not including excavation. This work was under the direction of Prof. A. H. Talbot, Professor of Municipal Engineering at the University of Illinois, Urbana, Ill.

NOTES ON RECENT FRENCH BRIDGE CONSTRUCTION.

(With two-page plate.)

Among the notable bridges which have been constructed during the last year or two, French engineers have contributed an important proportion. Some of these have been mentioned in Engineering News from time to time, and the accompanying notes and illustrations explain these more fully, and also give the general details of other structures not heretofore described. We have abstracted these descriptions from the various numbers of "Annales des Ponts et Chaussees" for 1898

FIG. 1.—THREE-SPAN STONE ARCH BRIDGE AT VERDUN, FRANCE.

Stone Arch Bridge at Verdun, France.

The handsome stone arch bridge shown by Fig. 1 was completed in May, 1897, at a total cost of $41,128. It crosses the River Doubs at Verdun, France, and has the following principal dimensions:

Total length	146 m. (478.88 ft.)
Width over all	6 m. (19.68 ft.)
Width of roadway	4.5 m. (14.76 ft.)
Width of foot walks	0.75 m. (2.46 ft.)
Center arch:	
Span	41 m. (133.58 ft.)
Rise	9.17 m. (30.06 ft.)
Thickness at crown	1.2 m. (3.93 ft.)
Shore arches, two:	
Span	38.5 m. (126.28 ft.)
Rise	8.52 m. (27.94 ft.)
Thickness at crown	1.2 m. (3.93 ft.)
Thickness of piers at springing line	4 m. (13.12 ft.)
Total amount of masonry	3,136 cu. m. (4,102 cu. yds.)

The curves of the intrados of the arches are half ellipses, springing from mean water level, and those of the extrados are circular arcs with a radius of 46 m. (157 ft.) for the center arch, and of 44 m. (144.32 ft.) for the shore arches. The foundation soil is a succession of beds of sand, gravel and very compact plastic marl; the piers being founded upon pneumatic caissons, and the abutments upon clusters of piles capped with a layer of concrete. The pressure upon the foundation bed at the piers is 2.9 kg. per sq. cm., and at the abutments 3.6 kg. per sq. cm., or, per square foot, a little less than 3 tons, and about 3⅝ tons, respectively.

The abutments, piers and main arch rings are of a bluish gray stone, quarry faced, except for narrow chisel lines, to delineate the curves of the extrados and intrados, the rough surface and somber color serving to make the main structure of the bridge stand out strongly. In constructing the spandrel arches, however, lightness and color were sought after by using reddish-brown bricks, accentuating their springing lines by a slight capital, making the arch rings project slightly, and using a nearly white stone for the spandrel walls. A simply molded cornice surmounts the spandrel arches, and carries the parapet. This parapet is built of light brick, with darker colored brick interspersed to form simple decorative figures, and is paneled by means of projecting buttresses at intervals. At the crowns of the arches and at the ends of the bridge simple cut stone panels are introduced to break the monotony of the brick work, and to mask partially the changes in grade which occur at the crowns of the arches.

The work of construction was begun in August, 1895, and the bridge was opened in May, 1897. No difficulties of note were experienced in the construction. The cost of the bridge per lineal meter was 891 frs., or, including foundations, 1,337 frs, and per cubic meter 41½ frs. and 48.78 frs., respectively. The Engineer-in-Chief was Mr. Jozon, and the contractors were Messrs. Boyer & Antoine.

The Red River Bridge, China.

In 1896, the French began the work of extending and widening the gage of the Langson-Phu-Lang-Thuong railway in the province of Tongkin, China. That portion of the extension south to Hanoi involved the crossing of the Red River by a bridge of unusual length, besides the building of three less notable structures over smaller streams. The proposed Red River bridge is illustrated in its general features by Fig. 2, which is a partial side elevation, and by Fig. 3, which shows half cross sections at different points. The total length of this bridge is 1,682 m. (5,516.96 ft.), or 237 ft. over a mile, and it is divided into two 78.7 m. (248.14 ft.) spans at the extreme ends, and nine 75 m. (246 ft.) spans, and eight 106.2 m. (348.33 ft.) spans, which alternate with each other. The form of the cantilever trusses, the transverse connections, floor construction, bearing shoes, etc., are shown with their main dimensions by the drawings. Only the piers remain to be mentioned. These are of masonry, founded upon pneumatic caissons, sunk to a depth of 30 m. (98.4 ft.), and having a base composed of a rectangle, 4.2×5.8 m. (13.77 × 19 ft.), terminated by two semicircles. The piers just below the coping has a section composed of a rectangle 2.7 × 5.7 m. (8,856 × 18.69 ft.), terminated by two semicircles 2.7 m. (8,856 ft.) in diameter.

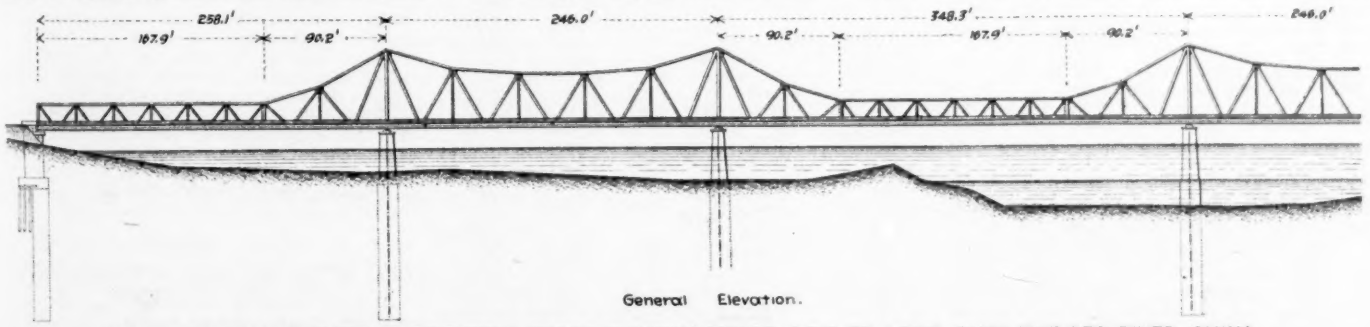


FIG. 2.—DIAGRAM ELEVATION OF SINGLE-TRACK RAILWAY BRIDGE, 5,517 FT. LONG, OVER THE RED RIVER, CHINA.

The Three-Hinged Arch Across the River Viaur in France.

One of the most notable metal arch bridges of recent years is the so-called Viaur Viaduct, built to carry the railway line of Carmaux-Rodez across the valley of the River Viaur in France. The metal work details of this bridge are not yet available for presentation, but the general character of the bridge has been described in "Annales des Ponts et Chaussees," from which publication we take the accompanying illustrations and description. Briefly described, the Viaur Viaduct consists of three metal spans flanked by masonry arch approaches. Its total length is 460 m. (1,508.8 ft.), and its length between approaches is 410 m. (1,344.8 ft.). The masonry approach arches, two on one side and three on the other, are each of 7 m. (21.96 ft.) span. The metal portion of the viaduct consists of two shore spans of 95 m. (311.6 ft.) each, composed of a cantilever arm of 69 m. (226.32 ft.) and a suspended truss of 26 m. (85.28 ft.), and of a three-hinged arch main span of 220 m. (721.6 ft.), c. to c. of pins, and 116 m. (380.48 ft.) high from the bottom of the valley to the base of rail. The rise of this arch is 53.731 m. (176.24 ft.). Fig. 4 is a diagram elevation of the structure.

Foundations.—Aside from the approach arches, which are in no way of especial note, the substructure of the Viaur Viaduct consists only of the four piers against which the feet of the arch ribs abut. Fig. 5 shows the construction of these. They are composed of "rough stone" masonry surmounted by three courses of cut stone masonry, the stones of each course of which are bound together by iron clamps set in lead. The manner of anchoring the arch ribs to the masonry is shown clearly by Fig. 5. It will be noted that an arched gallery in the masonry permits access to the anchorages. Limestone was employed for the rough stone masonry set in a mortar of lime of Teil, and granite set in cement was used for the cut stone capping. Great care was employed in laying this capping. The mortar joints were made only from 10 to 12 mm. (0.39 to 0.47-in.) thick between courses, and the masonry of each course as a whole was dressed to a plane on top before commencing the course above. The pressure of the abutments upon the foundation bed is 7 kg. per sq. cm. (about 100 lbs. per sq. in.)

Superstructure.—The metal structure consists of two arch ribs hinged at the crown and abutments of the center span, and continuing as cantilevers over the abutments to form, with the suspended trusses, the shore spans. Fig. 6 is a transverse section at the abutments, which with Fig. 4 indicates clearly the character of the transverse bracing between these arch ribs. All the structural work, except the suspended spans and rivets, which are of iron, is of steel. The erection of the shore spans is being accomplished by means of falseworks which envelop the entire steel structure, but the center span is being erected as a cantilever, anchor ropes serving to support the two halves until they meet at the crown. The total cost of the Viaur Viaduct is estimated at 2,450,000 fr. The engineer-in-chief is M. de Volontat.

The Bizerta, Tunis, Highway Bridge.

The city of Bizerta, Tunis, is located on the shore of the Mediterranean Sea, in the immediate neighborhood of two quite large lakes which communicate with each other, and also with the sea itself. Until recently the channel connecting the larger lake with the sea was quite small, having a depth of only about 1.55 m. (5.08 ft.), while the lake itself was from 12 to 13 m. (39.36 to 42.64 ft.) deep, and

to get the use of the lake as an anchoring ground this channel was enlarged to a depth of 9 m. (29.52 ft.), and a width of 100 m. (328 ft.). This enlargement of the canal made a serious break in the highway connecting Bizerta with Tunis, which in the vicinity of Bizerta has a considerable important travel, and consequently made a bridge of considerable dimensions necessary. The form of structure adopted is shown by Fig. 7, and is of the same type as the bridge built at Bilbao, Spain, after the designs of Messrs. Palacio and Arnodin.

As will be seen, the bridge consists of a high level girder upon which runs a carriage having suspended from it a platform or basket at about the level of the canal banks, onto which are run the loads to be transported from shore to shore. The high level girder or truss is suspended from cables passing over towers and securely anchored at the ends, like the stiffening truss of a suspension bridge. It is 44 m. (144.3 ft.) above the approach platforms, which are about 1½ m. (4.92 ft.) above the mean water level of the canal. The towers are spaced 109 m. (357.52 ft.) apart, c. to c.,

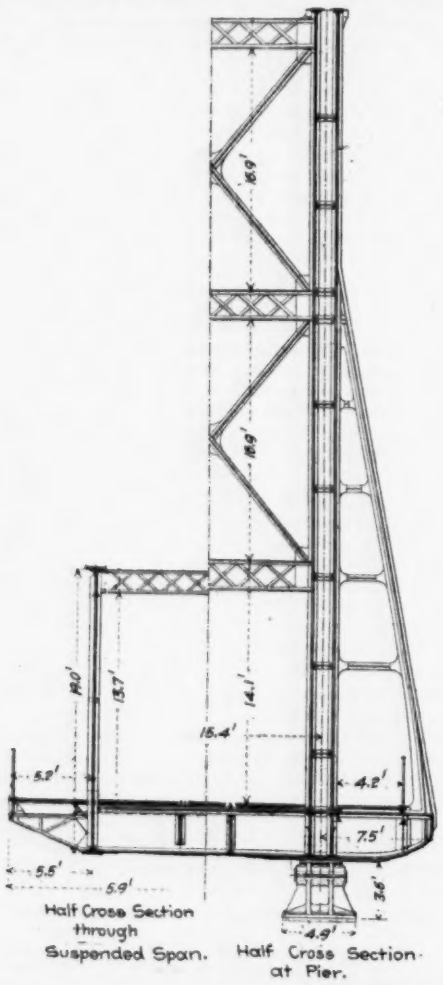


Fig. 3.—Transverse Sections of Red River Bridge, China.

and their total height is 59.75 m. (195.98 ft.). Their construction is clearly shown by the drawings, as are the various principal dimensions of other parts of the bridge. The suspended platform or carriage is 7.5 × 9 m. (24.6 × 29.52 ft.), and has a capacity of 25 tonnes in high winds and 55 tonnes at other times.

The operating machinery consists of a reversible winding engine of 15 HP., with a 10-HP. boiler which is ample to handle the intermittent loads, mounted in an operator's house, 5 × 8 m. (16.4 × 26.24 ft.), supported by the main portal arch of the Bizerta Tower. An extra boiler is provided in case of accident. An endless rope attached to opposite ends of the trolley carriage and passing around the engine drum operates the trolley and its suspended carriage.

The construction of this bridge was begun in July, 1896, and it was completed in June, 1898. Since its completion the bridge has been regularly operated with entire satisfaction, it is stated. During this time also it has withstood a very heavy wind storm without damage. The total cost of the work, including land damages, machinery and contingencies, was 560,000 fr.

THE ASPHALT CO. OF AMERICA has been incorporated in New Jersey, with an authorized capitalization of $30,000,000. The incorporators are said to be Philadelphia men, including Sydney F. Tyler, President of the Fourth National Bank; Geo. A. Huhn, of Geo. A. Huhn & Sons, bankers and brokers, and E. A. Ballard, of Shapley & Ballard, attorneys. The object of the company is said to be the control of the asphalt business of the United States.

LICENSES FOR MOTOR VEHICLE OPERATORS will be required in the future by the City of Chicago, where the number of self-propelling vehicles is increasing at a remarkable rate. This action has become necessary as a result of the many accidents due to incompetent operators. The examinations will inquire into the applicant's general ability only so far as necessary to determine his fitness as an operator of motor vehicles and will include a physical test.

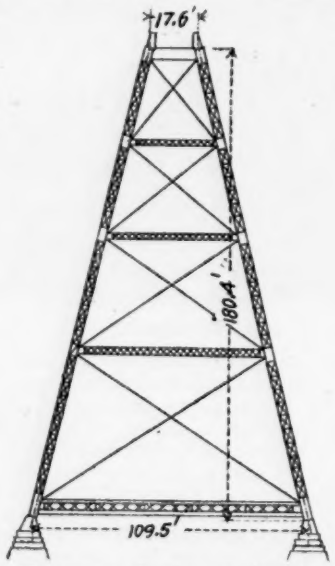


Fig. 6.—Transverse Section at Abutments, Viaur Viaduct, France.

A HILL-CLIMBING TEST OF MOTOR CARRIAGES was made during the recent Automobile Club exhibition in London, England, in which 19 vehicles participated. The test was made on a stretch of road 817 ft. long, with an average grade of 11.19%, and included a run up the hill for speed and a run down the hill to ascertain in what distance the carriages could be stopped. The following table given by the "Engineer" of London, shows the results of the tests:

Motive power and name.	Stopped in ft.	At speed of miles per hr.	Gradient 1 in	Speed of ascent miles per hr.
Barriere tricycle	86	14.62	13.85	13.92
Electric: Dog cart.....	90	.....	13.85	10.96
Riker car	98	15.47	12.9	5.71
Petroleum: Wagonette	96¾	14.88	12.0	4.0
Phaeton	47	15.43	12.9	5.35
Wagonette	48	14.65	12.9	4.41
Tight car	95	12.47	12.9	5.46
Dog cart, Benz.....	103	15.03	12.9	5.98
Ideal, Benz.	82½	16.23	13.85	9.77
Phaeton	38	10.41	12.9	6.99
Car.....	131	21.28	12.0	5.75
Car	74¾	6.99	12.9	7.42
Phaeton	37	15.96	12.9	7.91
Phoenix car	68.6	14.09	13.8	4.58
Car. Panhard.....	94	13.11	12.9	8.75
Vallee	106	20.82	12.92	7.8
Mers	20.6	10.8	13.8	7.08
Hercules	87	13.03	12.9	6.11
Orient express	45	13.34	12.9	5.17

MOTOR CARRIAGE LINES IN SCOTLAND are reported to be doing a good business. According to a consular report just issued this form of vehicle was introduced in Edinburgh by a local company early in 1898. During the spring and summer of the same year, a carriage with a seating capacity of eight was run regularly between the post-office and the Forth Bridge, a distance of about nine miles. This method of transit gradually won public favor. As the traffic increased, other cars were added. The company, finding the Forth Bridge experiment a success, decided to run motor carriages on certain routes in the city. Since these routes were established, the public patronage has increased steadily, and the returns of the company during the current year have been quite satisfactory. The rate of fare is practically the same as the rate on the corporation tramways, averaging 1d. (2 cts.) per mile. This is about the rate also in Glasgow, Dundee, Aberdeen, Hamilton, Falkirk and other cities where motor carriage companies are operating. It is announced that the directors of the Glasgow exposition of 1901 are making extensive provision for an exhibit of these vehicles in the locomotive and transportation department, with facilities for the practical demonstration of their merits. The carriages now in use in Edinburgh and district are of British manufacture.

BOOK REVIEWS.

LA BICYCLETTE, SA CONSTRUCTION ET SA FORME.—Par C. Bourlet, Docteur des Sciences, Membre du Comite Technique du Touring-Club de France. Paris: Gauthier-Villars, Publishers. Paper; 10 × 6½ ins.; pp. 228; 200 illustrations. 4.50 francs.

This material was first published in a series of articles in "Le Genie Civil," and it practically forms a sequel to the work already published by the same author and entitled a "Nouveau Traite des Bicycles et Bicycletes," reviewed in our issue of Oct. 6, 1898. While written for engineers and the designers of bicycles, it is also addressed to wheelmen and to all interested in their machine to the extent of knowing all about its parts and power. The history of the bicycle is given from 1790 to 1898, with illustrations of the various radical steps made in its development. The descriptive matter, very fully illustrated, divides itself into discussions of the frame, steering appliances, pedals, transmission of power, change of speed, wheels and tires. The various small accessories have a chapter to themselves, and then follow advice in the choice of wheels and notes upon hygienic precautions to be taken by wheelmen, and the avoiding of accidents. A theoretic discussion of the action of ball-bearings concludes the work.

DIE ANKERWICKLUNGEN UND ANKERKONSTRUKTIONEN DER GLEICHSTROM-DYNAMOMASCHINEN.—By E. Arnold, Professor and Director of the Electrical Technical Institute and the Technical High School at Karlsruhe. Berlin: Julius Springer. Third edition; cloth; 6½ × 9¼ ins.; 418 figures; 12 plates; pp 736; 15 marks.

This is a treatise upon the subject of armature winding and armature construction for direct current machines. The first half of the book is devoted to a very full description of the methods or principles of winding, which are also illustrated by a series of excellent diagrams. Unlike many books, practically no space is given to an introduction, the author adopting the better course of treating the subject as indicated by the title from the first page. Windings and connections for the various forms of armatures, such as drum, ring and disk for two, four or more poles are very fully considered. Equations are used, which will enable the designer to easily select a form of winding with a feeling of certainty as to its correctness. Armatures for the so-called unipolar dynamo are considered briefly, as are also multipolar two-brush types. The designing and placing of conductors, the effects of armature reaction, disposition of magnetism over the field pole faces are also considered. Open coil windings, such as are found in the Brush and Thompson-Houston arc generators, and the arc machines of the Westinghouse Co., as well as other types, are briefly described.

The second portion deals with the practical or constructional details of direct current armatures, and includes discussions and formulas for the design of shafts, methods of mounting the laminated cores, and other mechanical features. Core losses in the form of hysteresis and eddy currents are considered briefly. Shapes and arrangements of armature slots, conductors for either slot or surface windings for drum or ring armatures and commutator design are briefly but well handled. Following this a number of armatures from actual machines are fully illustrated and briefly described, affording an excellent idea of how designs are prepared by manufacturers. The 12 plates forming the conclusion of the book are not its least valuable feature. They were prepared from actual working drawings, and while small enough to be convenient, every detail is well brought out.

ANNUAL CONVENTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The most largely attended meeting ever held by the American Society of Civil Engineers was convened last week at the Stockton Hotel, Cape May, N. J. Through the courtesy of the Pennsylvania Railroad, special trains were run to Cape May from New York and from Philadelphia on Monday, June 26, and transportation was furnished not only on these but on the other Pennsylvania lines from Washington and Pittsburg eastward. The result of these favorable arrangements, together with the attractions of a famous seaside resort during the last week in June, was the assembling of the largest gathering ever held under the society's auspices and the largest meeting, we believe, ever held by any engineering society in this country. The total number of names regis-

tered during the meeting was nearly 600, a number so much greater than that originally planned for, that the resources of the hotel were at first subjected to a strain which threatened to exceed their elastic limit. Fortunately, however, the patience, good nature and resourcefulness of the guests had no limit, and in due time everyone was made comfortable.

The first formal session on Tuesday, at 10 o'clock, was devoted to an address by President Desmond Fitzgerald, its subject being on the earliest American engineers and their work. (We printed this address in our last issue.) Following this, Mr. E. L. Corthell gave a brief account of the International Congress of Navigation, held last year at Brussels. Mr. Corthell attended this congress as the authorized representative of the United States and of the society, and the report of its proceedings with translation of its principal papers will, it is expected, be printed as a government publication, and will thus be made available to engineers.

This concluded the morning session and the members at once made haste to follow the rule laid down by the immortal Squeers, and they put into practice the ideas Mr. Corthell had just expounded by donning bathing suits and pursuing the most primitive of all forms of water navigation until luncheon time.

Bridge Strains—Discussion.

The attractions of the surf and the delays of the dining-room combined to prolong the luncheon hour, so that it was full 14.50 o'clock, according to the society's standard time, when the convention was again assembled to discuss questions laid down in the program as follows:

Should the use of the method of wheel concentrations be discontinued in determining the stresses in railway bridges?

In view of present knowledge of the effect of repeated applications of load, should fatigue formulas be used in bridge design?

The discussion of these questions was prolonged for some time, but it may be stated at once that the sentiment was practically unanimous in favor of answering both these questions in the affirmative. In fact, the members vied with each other in poking fun at the old plan of specifying wheel loads for use in computing bridge strains. As Mr. Geo. S. Morison said: "We set out to build a bridge to last at least 50 years (and which probably will last 25 years), and we proportion it for a certain locomotive which will be obsolete in two years and a half."

Some 25 years ago it was the custom to state the weights on each wheel of a locomotive to 10 lbs., and to state their respective distances apart to the nearest inch; such ridiculous refinements have fortunately passed, but we should go further and abandon the use of wheel concentrations altogether.

Mr. Gustav Lindenthal called attention to the fact that the stiffness of tracks, floor systems and stringers caused the weights on the driving wheels to be distributed in any event, and made the use of driving-wheel loads a false and unnecessary refinement. He also pointed out that the Launhardt-Weyrauch formula, which has been so generally used, rests on no sound basis of either theory or experiment. For short span bridges, it adds a trifling amount of metal, and its only practical effect is to add to the labor of computing the strains. For long spans, however, the added weight of material becomes a serious matter, and the result is that the bridge is loaded down with useless metal which adds much to its cost but nothing to its strength or durability. He thought there were indications that the increase in the size of locomotives, or rather in the concentrated load which they imposed on track and bridges, was nearing an end. A weight of 150 tons concentrated on a wheel-base of 15 ft. may be taken as the limit of the locomotive weight for which bridge designers must provide. Beyond this point, the weights become so great as to approach the crushing strength of the steel in the rails and tires.

Prof. P. C. Ricketts said that there was a much more serious objection to the use of both the fatigue formulas and the wheel concentration than the mere additional labor which they involve. Their accuracy is only apparent, not real, and they are based on false assumptions so that their use adds nothing to the engineer's knowledge of the actual strains in his structure under conditions of service.

Alluding to the great increase in rolling loads, due to freight cars, Mr. Morison said that the Goodwin Dumping Car Co. is building a car to carry a load of 125,000 lbs. of ore and a total weight of 167,000 lbs., on a wheel-base of 36 ft., or a weight of nearly 5,000 lbs. per ft.

Mr. Morison also described his plan of assuming loads for computing bridge strains. He assumes: (1) A heavy concentrated load; (2) a lighter uniform load, and (3) a graduated loading between the two. In addition, he uses lower unit strains for those members which are most directly strained by the loading. He proposed, as a standard for heaviest loading, a concentrated load of 200,000 lbs. distributed over a length of 20 ft., and followed after an interval of 10 ft. by a uniform load of 5,000 lbs. per ft.

The subject was further discussed by Messrs. Snow, Cole, Breithaupt, Cowles, Seaman and others, but there was unanimous agreement as to the propriety of abandoning both the wheel concentration and the fatigue formulas.

Breakwater Construction.

At the evening session Major C. W. Raymond, Corps of Engineers, U. S. A., exhibited to the members a number of lantern slides showing the work of construction on the Delaware breakwater. He explained that at the outset of this work in 1828 the precedents laid down by the French engineers in the design of the Cherbourg breakwater were adopted. In the more recent work, however, the principle has been established that the stability of the slopes of a breakwater made of random stone depends upon the size of the stone which are used. An effort has been made, therefore, to secure the largest possible stone, and to dump the largest pieces on the exposed side of the work. Stones of 3 to 7 tons weight are common sizes, and with the powerful hoisting gear used by the contractors these can be handled more cheaply than stones of smaller size. The result is a considerable decrease in the section of the breakwater and of its cost per lineal foot constructed. Major Raymond pointed out as a curious illustration of the far-reaching effect of a single change in engineering practice that the substitution of steel in place of wrought iron for the wire ropes used in the derricks had greatly increased the size of the stones which the contractors could handle, and consequently the stability and possible steepness of slope of the breakwater.

Business Session.

On Wednesday morning the first matter taken up was the election of the Nominating Committee, which is to select the candidates to be voted for at the next annual election. As most of our readers will remember, this society has elaborated this matter of making nominations to a remarkable extent. The entire membership of the society is divided into seven geographical districts, and at the annual convention separate meetings of the members from each of these districts are held, and some resident of the district is selected to serve as a member of the Nominating Committee; this selection, however, has to be confirmed by general vote of the convention.

The results of the several district meetings were reported on Wednesday morning, and the Nominating Committee selected was as follows:

District No. 1, Alfred W. Trotter; No. 2, Geo. B. Francis; No. 3, T. McC. Leutzé; No. 4, W. D. Wilkins; No. 5, Augustus Mordecai; No. 6, J. A. Ockerson; No. 7, Hiram Savage.

The results of the expression of preference of the place for the next annual convention was then announced by the Secretary. There were 204 votes cast, of which Paris had 41, Washington 15, St. Louis 10, Boston 9, Chicago 8 and Cleveland 7. The remaining 114 votes were scattered among a list of about fifty different places, most of which had one or two votes only.

The reading of this list so much amused the audience that a motion to hold the next convention in Porto Rico was made and seconded, and was about to be carried when it was amended by substituting Dawson City. The usual course was then taken of leaving the whole matter to the Board of Directors. The vote as to the time of holding the next summer meeting developed a similar variety of choice, but June appeared to be the favorite month.

Mr. Samuel Whinery presented a resolution, which was adopted, instructing the Board of Direction to endeavor to have the complete statistics of municipal and other public works collected by the census department.

Mr. Henry B. Seaman presented a resolution that the Board of Direction should consider the advisability of paying the traveling expenses of members of the Nominating Committee who came from a distance to attend its meeting. This started a long discussion, in which the sentiment was on the whole adverse to the payment of such expenses from the Society's funds, but in favor of making some change which would give members of the Nominating Committee residing too far away to attend the meetings an opportunity to take an active part in the selection of candidates by correspondence. The Board of Direction was instructed to take the whole matter under advisement and report at the next meeting.

Mr. John F. O'Rourke called for the report of the Committee on Uniform Standard Time, and none being forthcoming he moved "that the Board of Direction take up the question of uniform standard time and settle it for all time." This is the old controversy over the proposed abandonment of the society's pet hobby, the 24 o'clock system, and of course it produced a fight. After repeatedly trying a vote by yeas and nays in which each side outdid the other in the amount of noise, a standing vote was taken and the motion was carried by a vote of 71 to 34.

Stream Pollution and Water Filtration.

The subjects announced for discussion at this session were the following:

(a) Should stream contamination by the sewage of cities be absolutely prohibited by law?
(b) Should the purification of the sewage of cities be compulsory; and is this feasible for large cities?
(c) Is filtration the coming solution of the pure-water question for cities?
(d) What is the proper friction coefficient for use in the design of riveted steel pipe?

Mr. R. E. McMath, of St. Louis, opened the discussion with a carefully prepared paper in which he handled without gloves Chicago's plan for getting rid of its sewage by sending it down the Illinois River through the new drainage canal. He declared that the Chicago scheme was without an originator—no one cared to assume the responsibility for its original conception—and it was now almost without a defender. Taking up the first of the above questions, he declared that the common-law principle that one must not so conduct his affairs as to injure his neighbor was sufficient to stamp the discharge of sewage into any living waters as illegal. He would also answer yes to the second question; in fact, he considered that any scheme in which no provision was included for innocuous disposal, did not deserve to be called a plan for a system of sewerage. As to its feasibility for large cities, he referred to the experience of Berlin and Paris as proof that, "it can be done, and we are the men to do it." As to the matter of filtration of water supplies, he thought that while filtration might promise a remedy for polluted water, it was far better to have the water as pure as possible to start with.

Mr. W. C. Parmly, of the Cleveland sewer department, said that ideal perfection always costs too much. We must be satisfied with what is reasonable. Streams of absolute purity are an impossibility in any thickly populated district. A good practical rule to follow is that no stream should be allowed to become so foul as to give off effluvia and offensive gases, and where streams are used as a source of water supply, all sewage or other pollution should, of course, be rigidly excluded. The extent to which sewage discharge may be permissible varies with the volume and velocity of the stream. Sluggish streams should be kept as free as possible from sewage pollution. He pointed out that the practice of turning storm overflows from a combined sewer system into running streams was really preservative of the purity of the streams, for under this system the first washing of the streets went into the sewers, and it is this first flow from the streets that is most foul. On the other hand, if the principle is laid down that no storm overflow from sewers into streams is permissible, we must have either the separate system of sewerage with all street washings going into the streams, or else we must make storm water sewers of such enormous capacities that their cost will be prohibitory. As an example of this, the Cleveland Park Commissioners recently objected to the turning of a storm-water overflow into a stream. It was found that if this were not permitted the sewer would have to be so much enlarged that its cost would be increased by $250,000.

Prof. Gardner S. Williams, of Cornell University, related an experience with the Detroit water supply, to illustrate his proposition that all flowing waters at some time or other in their course would be used for water supply. Ordinarily the typhoid rate of Detroit is very low, but in the summer of 1892 a serious epidemic occurred, so that the typhoid death rate in that year was exceeded by only four American cities. The cause was a mystery for some time, but was finally traced as follows: During the previous fall the city of Port Huron, 60 miles north of Detroit, had considerable typhoid. The sewers of Port Huron discharged into Black River, a sluggish stream with very little flow. In the spring of 1892, work was begun by the government upon the dredging of Black River to improve it for navigation and deposits of foul material from the years' accumulation of sewage in the stagnant reaches were removed by dredging, some of these deposits being 8 to 12 ft. in depth. This material was taken away in scows and dumped in the swift current of the St. Clair River. Allowing for the time necessary for the water thus polluted to reach Detroit and for the period of incubation of the typhoid germ, the course of the fever in Detroit exactly coincided with the dredging of the polluted material and its deposit in the river, 60 miles above. Bearing in mind the great volume of the Detroit river, the purity of its waters in their ordinary condition, and the fact that Lake St. Clair with its wide area and low velocity of flow lies between the two cities, this case of typhoid infection through water supply ranks as one of the most remarkable on record.

Mr. Peter Milne said that the American Water-Works Association, of which he is the secretary, has been considering the subject of stream pollution for eight years, and has about decided that state legislation will not answer, and recourse must be had to Congress.

Mr. Kenneth Allen, of the Baltimore Sewerage Commission, said that the report of the River Pollution Commissioners of Great Britain is at present the best authority available as to the extent to which sewage discharge into living waters is permissible. The character of the stream has a great influence upon the percentage of pollution which it can endure. Legislation on the subject must at present be tentative, for each case must be considered by itself, and a hard and fast rule to fit all cases will be sure to work much hardship and injustice. He had much hope that the septic tank system might solve the present difficulties in the land disposal of sewage, yet the Baltimore sewerage commission had refrained from recommending its adoption, as being still in too experimental a stage.

Mr. James Owen and Mr. Harrison, of Jersey City, said that the question as stated on the program was far too broad. Cities on tidal waters must necessarily discharge their sewage into salt water, and since such

waters are never used for drinking, no harm is done so long as the dilution of the sewage is sufficient. Nevertheless, the city of Newark is to-day enjoined from discharging sewage into a tidal stream, and if such actions are to be sustained in other courts, the great cities on tidal waters have a most serious situation on their hands.

One other speaker, whose remarks concluded the discussion, declared that the final solution of the whole water question was a double system of supply and a double system of sewers. Paris has adopted this solution for both its sewers and its water supply, with excellent results.

Electric Motors vs. Steam Locomotives.

The last formal session of the convention was held on Friday morning and the subjects set were as follows:

What are the economic conditions under which electricity may be profitably substituted for steam in the operation of branch railroad lines, and what are the engineering requirements to be considered in such substitution?

What is the present development of the so-called Telferage system for moving either freight or passengers? What are the conditions under which that system is preferable to movement by rail, and what is its adaptability to still further application in competition with rail lines?

Mr. H. S. Haines said that the first of these questions was one which had occurred in his own practice. It had appeared to him that the only case where electric traction could be successfully used for branch lines was where current could be purchased at a low rate from manufacturing establishments along the line, some of whom developed it from water power.

Col. H. G. Prout said the question was purely one of traffic conditions. Except where it was necessary to run frequent short trains doing practically a suburban or street railway business, he saw no advantage in electricity. So far as the cost of power is concerned a 1,000-HP. locomotive costs $10,000. A stationary power house of equal capacity costs about $80,000; and if there is any gain in fuel economy through the use of the electric motor, it will be more than offset by the greater first cost of the plant. Further, the fuel cost is a small item, after all, in the total expense of railway operations. The advantage of the electric motor over the locomotive, if any exists, must be sought in other directions than in fuel economy. Mr. E. S. Davidson instanced a branch line near Pittsburg which was at one time operated as a trolley line but is now operated by locomotives.

Prof. Webb, of the University of Pennsylvania, said that the electric motor was especially advantageous on steep or grade mountain lands and also for the operation of railways where small first cost was an essential and the line was made to fit the country with any grades up to 10%. Mr. E. Wegmann said that the steam motors could be designed to climb steep grades if necessary. He had run a steam street car up a 10% grade. Mr. Baldwin pointed out that where heating of cars was important the locomotive would do the work more economically than the electric current. Prof. D. C. Jackson, of the University of Wisconsin, as an illustration of the great consumption of power required for electric heating, said that some of the Western street railways expect to use as much power in winter to heat their cars as to propel them.

The subject was further discussed by Messrs. Robert Moore, J. J. R. Croes, Gustav Lindenthal and Oberlin Smith, and took at times a much wider range than that called for by the questions above. Mr. Haines summed up very fairly the results of the discussion by saying that in the present state of the art, electric traction appears to be only successful where the traffic is either urban or suburban in its character.

After suitable resolutions had been adopted acknowledging the courtesies of the Pennsylvania and Philadelphia & Reading railways, the final adjournment was taken.

Excursions.

On Thursday about half the visitors took part in an excursion to Atlantic City, given by the courtesy of the Pennsylvania R. R. On Saturday the start was made at an early hour from Cape May to give time to visit points of interest in Philadelphia. Arriving at the Reading terminal in Camden, the party were taken by ferryboat to the Cramp shipyards, where an hour was spent in passing through the shops and examining the two big Russian war vessels now on the stocks. The keel for the new "Maine" has been laid, and her sides are beginning to assume shape, while the "Alabama," which was launched some time ago, is nearing final completion. From the ship yards the party was taken by special train over the Reading lines to the Falls of Schuylkill, and thence down to the entrance to the new subway. The engineers' train then had the honor of being the first passenger train to pass through the subway. Stops were made at different points to enable the engineers to view the work, and the party was finally landed in good condition and very hungry at the Reading terminal station. Here an excellent luncheon had been prepared, and such justice was done to it as the brief time available permitted. The New York members of the party then took a special train over the Reading Railroad to New York city. Others remained in Philadelphia, and after a luncheon at the Broad St. station spent the afternoon in various excursions which had been planned for their entertainment by the Philadelphia local committee, to whom no small credit is due for the success of the convention and its great enjoyment by all whose good fortune it was to be in attendance.

THE BIENNIAL CONFERENCE OF THE INSTITUTION OF CIVIL ENGINEERS.

In our last issue we gave quite fully the report of the proceedings of Sections I., II., III., IV. and VI., of the biennial conference of the Institution of Civil Engineers which took place at London, June 7, 8 and 9. The following is a report of the proceedings of Sections V. and VII.:

Section V.—Shipbuilding.

SWIFT PASSENGER STEAMERS OF MODERATE SIZE.

By Edwin Lewis Martin, M. Inst. C. E.

To maintain a uniformly high speed at sea in all weathers needs a very large ship. The author remembers coming across in the "Campania" on her maiden voyage, when she steamed on one day approximately 550 knots, yet during the exceptionally heavy gales in the Atlantic recently, it was reported that her day's run dropped down to 260 knots. It is only necessary to consider the effect on the speed of a 30-knot destroyer driving against the gale that retarded the "Campania" to have it convincingly brought home to the mind that "passenger steamers of moderate size" can only be "swift" in moderate weather; in rough weather they must ease down. Their high speed is subject to the proviso of "weather permitting."

The limiting conditions compelling moderate dimensions are: Small funds for first cost or running expenses; the sources of revenue or earning power few or small, available draft of water limited, or, shortness of voyage. The problem then, putting it somewhat paradoxically, is, to obtain great power with the lightest and strongest machinery in the largest ship up to the limiting conditions; that is, the lightest weight of engines and boilers consistent with the greatest power that can always be exerted for continuous work without risk of breakdown; the ship being the largest, safest, strongest, most easily driven, and most comfortable floating hotel—in fact, the best sea-boat that can be built up to the limitations imposed by considerations of success in commerce.

The following questions will require exhaustive consideration to obtain a right solution:

1. Speed:—

(a) The maximum I. HP. per ton of weight, and highest piston speed suitable for continuous running; the number and arrangement of cylinders and boilers; the balancing of the engines; the efficient and convenient arrangement of bunkers to facilitate coaling and stoking, etc.; the most suitable type of boiler, ordinary marine with forced draft or water-tube.

There appears to be little to choose between ordinary marine-boilers with forced draft and the large-tube type to develope say 6,500 HP. for a voyage of 1,000 miles; whilst the small-tube type shows a saving in weight, but requires slightly more space, and in the capacity for continuous steaming they are inferior to the marine type. So far as concerns passenger-ships, therefore, water-tube boilers are in the experimental stage. The relative advantage of single and twin-screw propellers, etc., must be considered, and the material, diameter, pitch, and surface.

(b) Dimensions.—The best proportion of length to breadth and draft of water must be selected.

(c) The Form.—Kirk's analysis of some successful vessels of this type; the coefficient of fineness; also Admiralty coefficients for various size ships and speed will assist in the determination of form. The author has found the following test of propulsive efficiency, in the case of vessels of the same type and intended for similar service, very useful. A "coefficient of efficiency" or "figure of merit" is attained by computing the tons of coal per 1,000 miles, per 100 units $D^{2}/_{3}$ per 10 knots, the reduction to 10 knots varying as the cube of the speed.

2. Safety.—This must be paramount, a sine qua non, and must on no account be compromised.

(a) It demands a strong hull and machinery, suitable proportions of length to breadth and depth, a proper regard to material, scantlings, factors of safety, structural arrangements, bearing surfaces, means for arresting and retarding corrosion, also wear and tear, and upkeep.

(b) There must be sufficient surplus buoyancy.

(c) Ample stability must be provided. The metacentric height, maximum angle and GZ, also range of stability, for various successful vessels, of similar type and size, under unusual light and working conditions, should be examined and compared.

(d) The water-tight subdivision should be so complete that in case of any one or two compartments being broached, the vessel should still float with sufficient buoyancy and stability, and in such trim that she might be safely navigated into port.

(e) Ample life-saving appliances must be provided.

3. Comfort.—The vessel should be as easy as possible and possess all the qualities that go to make a good sea-boat; bilge keels will tend to reduce rolling; structural framing and shell-plating surrounding the shafts will tend to reduce the pitching motion without materially affecting the speed, if they are rightly formed, and give strength and rigidity to the structure. There should be a simple, suitable, spacious, and convenient arrangement and position of state-rooms, public-rooms, promenades, crew's quarters, and lavatories; an artistic treatment of decoration of public-rooms, and throughout the ship plenty of light, and air and warmth. Simplicity in arrangements for efficiently storing and preserving food, cooking and serving, and throughout the purser's department generally, should be aimed at, and the most compact silent and quick-working appliances for working baggage, stores, mails, and any light goods and parcels that this class of vessel may have the capacity to deal with, will conduce greatly to the comfort.

Discussion.—Various noted naval designers took part in this discussion; but the most notable point brought out was the important gain that could be made in reducing the weight of the hull, by using a higher grade of material which permitted a reduction in the section of the framing. Two channel steamers were recently built, one to class 100 A at Lloyds, and the other to a classification which waived the need of registry, so that the scantling was made enough lighter to reduce by 20% the weight of the hull. As a result, the lighter vessel made the same speed as its rival with 40% less power. The views of the author respecting water-tube boilers were opposed by Mr. Yarrow, the torpedo-boat builder.

MERCHANT STEAMERS FOR WAR PURPOSES.

By John Harvard Biles, M. Inst. C. E.

We may reasonably assume that the modern fast ocean passenger steamers are better able to maintain their speed at sea than warships. Their every-day business is to run at some speed called full speed, and most of them do not run at any other speed. It does not follow that they cannot steam easily at lower speeds, but a ship which ordinarily does not steam at full speed is more likely to fall short of maintaining full speed over long periods than one which is in the habit of doing it.*

In consequence merchant ships have been considered to be most suitably used as scouts or despatch-boats, and no attempt has been made to give them an armament equivalent to warships of anything like their size, power, and speed. Some of the results of arming and fighting the mercantile cruisers of the United States navy seem to point to the ability of these vessels to cope with thoroughbred warships.

Does not the result of modern sea-fighting point to the conclusion that a ship is more likely to be disabled by her crew being driven from their guns than from her being sunk from the effects of shell fire? If this is so, the extra subdivision and protection of buoyancy and stability of a warship over a merchant ship may not be called into play, and the fight between the two will become one of guns versus protection of gunners. This leads to the consideration of the question of portable protection for gunners in the merchant ship.

In the first-class cruisers, casemates are built into the ships. These would be impracticable in a merchant ship. But guns with shields are portable enough, and would place a merchant ship in a very favorable position compared with a second-class cruiser, as her size and deck area allow her to mount a much larger number of guns. In a paper which I read in 1894 before the Institution of Naval Architects I endeavored to show how large mail-steamers could be made as fit to fight as many first-class cruisers. Portable side armor was proposed, which should be ready for bolting on in time of war.

It is worth discussing whether, having employed vessels valued at £100,000 to £500,000 each as scouts and transports, it is not desirable to go a little further and make them able to do more by arming and protecting them so that they can meet second-class cruisers with the chances in their favor, and with a fair chance of holding their own against a first-class cruiser.

The experience of recent wars points to the desirability of having vessels which can carry large coal and store cargoes, and which have facilities for readily transferring these cargoes to warships at sea. This work could be well done by some of the large freight carriers of lines which carry mails. Special appliances would have to be fitted to these vessels, which might or might not carry these appliances in their regular work. In the construction of these vessels special consideration might be given to their use for such purposes. Some large freight carriers have ocean speeds of 15 knots, and such vessels would be of great service in time of war.

In the matter of position of machinery in relation to the water-line, the later vessels of moderate and large size have their machinery and boilers not far, if anything, above the water-line. With a little consideration to the question in the early stages of design and construction it is easy to arrange the structure so that the coal which these vessels carry will give protection. Twin-screw engines and increased revolutions are tending to make merchant ships more safe in this respect.

The discussion on this paper was in the nature of hearty approval. It was pointed out that there is, after all, no great difference structurally between a fast cruiser and a fast passenger steamer, and by spending a small part of what is now applied to building and maintaining cruisers, the government could have a large number of passenger vessels so designed as to be promptly available in case of war.

RECENT DEVELOPMENTS IN CARGO-STEAMERS.

By Edwin William De Rusett, M. Inst. C. E.

No. 1. Type.—Among the varieties introduced within the last seven or eight years may be mentioned the shelter-deck and turret types. The former has been evolved out of vessels having a poop, bridge, and forecastle, the intervening spaces having been gradually shortened—as in the "Westmeath" in 1894—until in the "Milwaukee," two years later, these erections were united by a complete deck with closed-in sides, so providing a covered-in space whereby seaworthiness, comfort, and strength have been increased and greater buoyancy secured.

The primary object of this type is to obtain large measurement capacity and provide suitable habitation for large numbers of cattle and horses. Such vessels are especially suitable for Atlantic service, whereas the type from which this has been developed is still the best adapted for Eastern traffic.

Although in this type the dead weight suffers somewhat, it has, in the later vessels, been increased by the addition of two or more bulkheads within the shelter-deck, whereby a diminution of free-board has been obtained. Vessels of from 6,000 tons to 12,000 tons dead weight have been recently built of this type with excellent results, combining as they do safety and comfort at sea with increased earning power.

As a cargo carrier, the "turret type" of steamer introduced in 1892 by Messrs. W. T. Doxford & Sons, is unique in its design, but although this type of vessel has other advantages, it has not the same relative internal capacity as the shelter-deck vessel previously referred to. Another departure from the usual type of steamer—the trunk type—was introduced in 1896. All these were probably the outcome of the American whale-backs which have done such good service in the large lakes.

Vessels especially constructed for carrying oil in bulk have also advanced in size and usefulness, being now adapted to carry general cargoes as well as oil, to suit the exigencies of the trade.

The addition of an awning deck to this type of steamer

*In the recent Spanish-American war the cruisers "St. Louis" and "St. Paul," "New York" and "Paris," could steam at 4 knots with the main throttle shut by the use of the exhaust steam of the auxiliary engines only. About 30 tons per day is the necessary consumption on auxiliaries, and the exhaust steam was sufficient to propel the ship at 4 knots and keep the machinery ready for immediate increase of speed to 20 knots. Eight minutes is the time given by the engineers as sufficient to make this change.

has rendered such a combination fairly feasible, although of course a tanker could never compete with a pure cargo boat, on account of increased first cost, and the large amount of broken stowage caused by their peculiar construction and design necessary for the efficient carrying of oil.

Quite recently a further advance has been made by the use of oil fuel in such vessels, liquid fuel having so high a flash-point as 200° F., rendering it safe and suitable for the purpose. It may be remarked this fuel is sometimes carried in the fore and after peaks, and sometimes in portions of the double bottom, from whence it is pumped to supply tank by special appliances.

No. 2. Size.—The size of vessels has rapidly increased of late, as may be observed from the following statement, which has been kindly furnished by Lloyd's Registry:

Statement Showing Numbers of Steamers (excluding War Vessels) under Construction in the United Kingdom on the 31st of March, 1895, 1896, 1897, 1898 and 1899, Between Certain Limits of Gross Tonnage.

	Steamers under construction in United Kingdom on 31st of March—				
	1895.	1896.	1897.	1898.	1899.
1,000 to 1,999 gross tons..	42	43	49	65	60
2,000 " 2,999 " " ..	43	49	54	68	40
3,000 " 3,999 " " ..	48	61	63	102	101
4,000 " 4,999 " " ..	29	21	15	25	34
5,000 " 5,999 " " ..	10	22	19	23	34
6,000 " 6,999 " " ..	4	5	11	14	20
7,000 " 7,999 " " ..	2	3	4	14	12
8,000 " 8,999 " " ..	3	3	4	3	1
9,000 " 9,999 " " ..	..	..	1	..	6
10,000 and above.....	1	1	3	4	15

Note.—The above includes passenger steamers.

During all the ages in which mercantile shipping has flourished there was not any noticeable growth in the dimensions and tonnage of vessels until after the first half of the present century, this being doubtless due principally to the fact that wood was the material of which they were built; but in this age of steel, and notably since the year 1890, the tendency has arisen and rapidly developed in the direction of building combined cargo and passenger vessels of the dimensions originally applied to high-class passenger steamers, and so much has this been the case, that whereas about ten years ago a cargo steamer of 300 ft. was considered of fairly large size, and 400 ft, exceptionally large, such vessels are now found to have reached nearly 600 ft in length, and between 12,000 and 13,000 tons dead weight, and there appears to be no reasonable limit to their extension, so far as the shipbuilder is concerned, but probably the limits of draft of water on the American side will be a determining factor in the problem.

List of Some of the Largest Cargo Vessels Built each Year by Harland & Wolff since 1889, Compiled from "Lloyd's Register."

Year.	Name.	Screw.	Dimensions (registered)	Tonnage. Gross.	Net.
1889.	"Ameer"	Single.	400.6×45.2×28.1	4,109	2,682
1890.	"Georgian" ...	Single.	442.6×45.2×31.0	5,088	3,318
1891.	"Montezuma"	Twin.	430.0×47.0×22.4	6,357	4,863
1892.	"Bovic."	"	470.0×53.1×23.9	6,583	4,230
1893.	"Cevic"	"	500.0×60.0×38.0	8,301	5,403
1895.	"Georgic" ...	"	558.7×60.3×36.0	10,077	6,570
1896.	"Pennsylvania"	"	560.0×62.0×41.0	12,891	7,861
1897.	"Cymric"	"	585.5×64.3×37.9	12,552	8,123
1899.	"Afric"	"	550.0×63.0×44.0	11,850	.....

As a further illustration, reference may be made to the development of the turret type of steamer, which in 1892 was represented by the "Turret," a vessel of 3,360 tons dead weight, and, in the present year, by the "Clan Colquhoun," a vessel of 8,400 tons dead weight, the increase in dimensions and tonnage having risen step by step in a similar manner to that expressed in the table.

No. 3. Construction.—Many modifications have of late years been made in this respect. First and foremost is the substitution of mild steel for iron. At the present time it is the exception for iron to be used in any part of a ship's construction, and substantially the whole of the vessels now building are of mild steel. The almost exclusive use of this high-class material has, in the aggregate, added enormously to the dead-weight carrying-power of the modern cargo vessel. There has been an increasing tendency of late years to avoid waste in the use of material in steel shipbuilding, and some of the more notable improvements that have been effected during the last ten years are, the overlapping and scarfing of shell plate butts, joggling at the landing edges of shell plating, decks, inner bottoms, and the plating of transverse watertight bulkheads, also the flanging of internal work wherever practicable. Girder frames have been very generally adopted in lieu of web and ordinary frames—being a simpler and more homogeneous form of construction. Hold beams have been dispensed with as far as possible, to give unbroken spaces for stowing large pieces of machinery, boilers, locomotives, tramcars, railway carriages, bridge work, etc.; and, to further facilitate stowage, wide-spaced hollow pillars, pitched about 20 ft, or even 35 ft. centers, have been adopted in lieu of solid pillars on alternate frames.

No. 4. Capacity.—As a matter of course, measurement and dead-weight capacity have increased with the increase in dimensions, especially when it is stated that, while it has grown in length, the cargo boat has developed in fulness, it having been found by experience that larger vessels of corresponding speed may be made fuller without impairing their efficiency.

Vessels are now being built having a capacity for about 25,000 tons of cargo at 40 cubic feet per ton, and a dead-weight of about 12,200 tons, whereas even as late as 1891 a steamer having a capacity for cargo of 8,750 tons, and a dead-weight of 6,750 tons, was considered to be a large vessel.

The following list of the cargo discharged by the "Milwaukee" in London in September will give an idea of the enormous and varied cargo carried by a modern steamer:

List of Cargo Discharged in London, September, 1897, from the S. S. "Milwaukee," Built by C. Swan & Hunter, Limited.

Dimensions of ship, 470×56×34 ft. 9¾ ins., with complete shelter deck.

514 head of cattle.	200 bags of starch.
132 horses.	189,200 bush. of corn.
640 sheep.	20,025 boxes of cheese.
18,412 bush. of oats.	399 cases of apples.
1,209 bales of hay.	11 cases of machinery.
13,149 sacks of flour.	16,737 deal ends.
51,629 pieces of deal.	5,723 pieces birch plank.
16,328 boards.	134 radiators.
4,398 pieces of lumber.	830 pails of lard.
195 tierces of lard.	5,730 bags of grape sugar.

This is said to be the largest cargo discharged in London up to this time, September, 1897. In this condition the ship had 11,100 tons dead weight. It is reported she was discharged in 66 hours' actual working time.

No. 5. Cargo Appliances.—It will be evident that unless a large vessel has a ready means of loading or discharging her cargo, she will be placed at a serious disadvantage when compared with smaller vessels having a quicker dispatch. It is also evident that detention in port neutralizes the advantages gained by speed at sea, consequently cargo appliances have received a great deal of attention. Winches are made larger than formerly, and are frequently worked with steam of main boiler pressure. The diameter of barrels and winch ends have been increased for quick working. Chain runners are giving way to light flexible wire ones, and a great increase has been made in the number and length of derricks. One derrick to each winch used to be the practice; now as many as two are sometimes fitted, with the addition of cargo spans between the masts; and, in one instance known to the author, 32 derricks and 10 winches were fitted to a steamer carrying 14,000 tons of measurement cargo. Derricks are also carried to lift 15 tons to 20 tons. Plenty of steam is a necessity.

The number of hatches has been increased; nine are now provided in the largest class steamers. The length of the largest has reached about 40 ft., but 26 ft. to 30 ft. by 16 ft. is usually found sufficient.

The following may be quoted as an instance of rapid discharge under ordinary working conditions: The "Monarch" arrived in Liverpool on the 1st October and left on the 9th, discharging a full cargo of 18,500 measurement tons, besides taking in about 1,700 tons of coal. This vessel has nine hatchways, and is fitted with twelve winches and eighteen derricks.

It appears to the author that the only limit to rapid dispatch is the capacity of the sheds and the facility with which cargo can be gathered or sorted and distributed.

No. 6. Ballasting.—As vessels now so commonly leave the ports of the United Kingdom in ballast and bunkers only, it has been found necessary to increase the proportion of water-ballast to give sufficient immersion for steaming. Consequently deep tanks have again been resorted to. These tanks are small properly ventilated holds available for cargo, or alternatively for water-ballast. The largest class of vessels frequently have two of these, besides the double bottom and peaks. A common proportion of water-ballast used to be about 1-10 of the load displacement; it has now reached from 1-6 to ¼. It is, however, advisable to give attention to the disposition of deep tanks, with the object of reducing the stresses at sea when in ballast trim.

No. 7. Economy of Working.—The ease with which these large vessels are propelled, and the speed obtained with full models is remarkable. Experience has proved that to produce an economically driven and steady cargo boat a good deal depends on the harmony of the lines, the proportion of bodies and the adjustment of power to the average speed required. These features have received more attention of late since competition has grown keener with the increase in tonnage.

As an instance, that of the "Monarch" may be cited. This vessel has a block coefficient of 0.810, and a dead-weight of about 11,600 tons. During two of her recent voyages to Montreal and New Orleans—outwards in ballast and bunkers, and home fully laden—she steamed 11.35 knots on the average, with a consumption of 48.3 tons per day, and other large vessels built by my firm have made similar performances.

On account of lightness of draft and other considerations twin-screws are becoming more common—a wise step, as shafts have been giving a good deal of trouble lately, and great loss of time and money has resulted. Twin-screw propulsion has, however, the drawbacks of increasing the cost, reducing the cargo capacity, and the speed is probably somewhat diminished with the same power.

Nothing is spared to make a first-class cargo-vessel efficient in every respect. For safety, shafting of the highest character and the most efficient steering-gears are provided; and for economy, bronze propellers, high-pressure steam, forced and induced drafts have been resorted to. The accommodation for officers and crew has been much improved, both with regard to position and size of cabins, while a general air of comfort pervades them. Electric lighting has become quite general, and no doubt the efficient lighting of the holds and hatchways by this means has materially aided in the present rapid handling of cargo.

Discussion.—The paper was discussed at some length by Mr. A. E. Seaton, who stated that two classes of cargo steamers had to be designed; one was for special cargo running on known routes to specified ports, and the other was for the general trade of an ordinary tramp. The latter class wanted especial skill in design. There was a tendency to increase the size in all classes of vessels. This was partly because docks and harbors had been provided which would take these big ships, but perhaps the chief cause was that with the large vessels the working expenses and cost of propulsion were comparatively less than with small ones. The difficulty of navigating these large cargo boats was far greater than that experienced with full-powered liners, especially when the vessels were light owing to the large surface exposed to the wind. An attempt had been made to get over this difficulty by increasing the water ballast, but the ordinary double-bottomed ballast tanks were not sufficient for this purpose. The practice of introducing double sides with water ballast had therefore been adopted. In this way more dead-weight of ballast was obtained, and there was a better distribution of weights. Iron as a structural material was not so obsolete as the paper had stated, some owners insisting on certain parts, such as decks and tank taps, being of iron rather than steel, as the latter was supposed to be more easily corroded. He considered that the joggling of plates gave a stronger structure and saved weight. He, however, viewed with apprehension the wholesale doing away with hold beams and the substitution of pillars in their place. He was of the opinion that the appliances for handling cargo were capable of great improvement, being to-day generally very much what they were 20 years ago.

MECHANICAL RIVETING AND CALKING DEVICES IN SHIPBUILDING.

By Robert Twentyman Napier, M. Inst. C. E.

A. Riveting Machines.—The only machines that need be considered in connection with shipbuilding divide naturally into two classes, viz.: (1) Machines that close the rivet by pressure; and (2) Machines that close the rivet by percussion.

The first of these is represented by the well-known hydraulic riveter, which made its appearance in the shipyard about thirty years ago, and by the less known but no less useful pneumatic riveter, which has perhaps half as long a working record.

These machines are too well known to require description; the inherent disadvantage of the class is that, as the working strains must be self-contained, no separate holder-up being possible, the use is limited by the depth of the gap, and, with the increase of the gap, there increases, in a greater ratio, the weight. An ordinary hydraulic riveter of 24-in. gap, such as is used for framing purposes, weighs about 10 cwts., and that one of 84-in. gap—perhaps the largest hitherto used in shipwork—weighs about 5½ tons.

The second class of reveter—viz., that in which the rivet is closed by percussion—is as yet only on its trial on this side of the Atlantic, although, in a measure, approved and adopted on the other. This riveter in its action approaches as nearly as may be to handwork, a hammer being kept in motion by a suitably-applied electric motor or by compressed air, the rivet-head being held up by a separate device.

A field seems to lie open to this class of riveter, and, if it be found that it can be relied upon, with ordinary care in handling, to properly fill the hole when closing rivets of 1 in. diameter and upwards, its adoption can only be a matter of time.

The convenience of being able to commence riveting at any stage during the work of plating is unquestioned, and the simplicity of handling a machine weighing pounds instead of hundred-weights is equally so. The noise that a percussive riveter makes is admittedly against it, and for this no remedy is forthcoming.

It is not in the nature of a riveting machine to close a counter-sunk rivet, leaving the point flush with the plating, and either a point more or less cupped must be accepted or the surplus metal must be chipped off. Since butt landings, are no longer thought an offence to the eye with shell-plating, so, no doubt, cupped rivet points might live down existing delicacy on the subject. With a bare steel deck it is otherwise, and here chipping is unavoidable. American practice is to do this chipping by means of a tool, also driven by compressed air, and then flatten the point by a second application of the riveter.

Two axioms have long ruled in connection with riveted work, the first being that the least diameter of hole that could be punched in an iron plate was represented by the thickness of such plate; and the second that a rivet of 1⅛ ins. diameter was the limit of the power of an average riveting squad to knock down satisfactorily. With the advent of the riveting machine, as applied to keel plates and top sides, the naval constructor will again have a free hand to proportion rivets and plates to advantage.

Assuming that the difficulties of rigging the gear do not stand in the way, there seems no a priori reason to prevent the bulk of shell-riveting being done by the hydraulic or pneumatic machine, provided that other considerations be made subordinate. By working all the plating clinker system—a system less objectionable now that joggled landings have banished slips—and proceeding from the keel plate upwards, completing one strake at a time, a riveter with a gap sufficient to take in the broadest plate would do the job.

In the case of decks, the same might be done, working inboards from the stringers and closing the center strake by hand; and even bulkheads might conceivably be done were the stiffeners erected first. To what extent it would be profitable thus to depart from present practice is matter for discussion.

B, Calking Machines.—Regarding the application of machines to the calking of ships not much is on record. Such machines, driven by compressed air, were brought before shipbuilders eight or nine yeas ago, and others, electrically driven, were also advocated. In the hands of their respective inventors, these machines did good work, and shipbuilders were not slow to buy them, but after the purchase came the trouble in the refusal of men to work them. In some yards the difficulty was got over, and the machines are, doubtless, now at work; but in others the opposition of the calker in possession of the job seemed serious, and the machines were laid to rest in the tool-store. In America the calking machine has a record to show, and its adoption on this side may yet be accomplished.

GRAVING-DOCK BLOCKS AND APPLIANCES.

By Arthur John Maginnis, M. I. N. A.

Concerning keel-blocks, the author said that the question whether wood or cast-iron keel-blocks were the better was still a matter of dispute, as each had undoubted advantages. The blocks should be spaced as far apart as possible to facilitate work upon the bottom, yet a limit should be set so that no risk will be incurred of straining the hull. They should be so designed as to be readily removed, but should be capable of being replaced and hardened up again to take their share of the load. In cases where it is necessary to get at the flat of the bottom for repairs, care should be taken not to overstrain blocks by the removal of those adjoining, and side cradles to aid in taking the strain should be used wherever necessary.

Side-Shores.—Modern science has, up to the present, not attempted any improvement on the primitive system of wooden shores hardened up with wood wedges, which no doubt answers the purpose fairly well, but is not by any means conducive to despatch.

In the consideration of this question, special attention should be given to the adoption of some more up-to-date appliance in the shape of horizontal steel shores, which could be travelled in or out from the side of the dry dock by hydraulic pressure and securely locked when in the correct position against the ship's side. All modern dry docks being generally fitted with hydraulic gear, this should not be an insuperable problem, and although the first cost would be considerable, the convenience and reliability of the system would soon recoup the outlay.

In dry docks, where the size of vessels varies greatly, difficulty would no doubt be found as to the height at which these hydraulic side-shores should be fitted, but this, like other novel engineering departures, would soon be got over after a little experience.

Lifting Appliances.—Owing to the fact that all vessels in dry docks nowadays have as a rule some heavy weights

to handle, it is absolutely necessary that special lifting-gear, capable of being used at any part of the dock, should be provided. At first sight this seems a simple matter, but closer study reveals a very intricate and elaborate requirement, owing to the wide range which must be embraced. For instance, it may be that a spare propeller about 20 tons weight has to be lifted out of a hold, say, 45 feet deep, through a hatch, the side of which is about 45 feet from the dock side, and the hatch coaming or bulwark, whichever is highest, is about 15 feet above the side of the dock. With these particulars, which are by no means abnormal, it can at once be seen that, to allow clearance for the propeller over the hatch or bulwark, at least 15 feet must be the height of jib over the hatch, so that a crane or machine is required which will be at least 65 ft. above the bottom of the dry dock, and have a clear outreach of from 50 to 60 ft. In addition to this unusual height and outreach, there must be added the great maximum weight required to be lifted, which ought to be at the very lowest 25 tons, so that to those intimate with crane design some idea of the magnitude of the required appliance may be formed.

But the massiveness and complication is still more increased by the fact that not only must the propeller be lifted from the hold and placed in the bottom of the dock without any overhauling of the lifting tackle, but after the propeller is clear of the hatch the crane ought to be able to travel along the dock side and deposit its load, say, 200 ft. in either direction. Met by such a bold demand as this, it is no wonder dock authorities have not taken steps to supply the want; but, speaking from wide experience in carrying out all sorts of overhauling and repairs about dry docks, the writer has no hesitation in saying that no appliance is more urgently wanted, either to secure greater despatch in carrying out the work, or to avoid risk of serious accidents which may be experienced when temporary gear is rigged for heavy weights.

Section VII.—Applications of Electricity.

ECONOMICAL TRANSMISSION AND DISTRIBUTION OF ELECTRICITY FROM A DISTANCE.

By Horace Field Parshall, M. Inst. C. E.

The subject may be subdivided into: (1) Economical generation. (2) Economical transmission; and (3) Economical distribution.

(1) Economical Generation.—There is not much to be said on the subject of economical generation, if the electrical conditions alone are considered, since the difference in efficiency, cost and maintenance between types of generators, whether continuous current, alternating current, or multiphase, is but small. In dealing with multiphase transmission, there may arise conditions where the use of step-up transformers will be found more satisfactory, commercially, than the use of generators working at very high pressure.

(2) Economical Transmission.—In the transmission lines, so far as the cost of conductors is concerned, and the efficiency in transmission up to the commercial limit of cost of generating or transforming apparatus, there is a direct gain in increasing the voltage where overhead lines are permissible. Where underground cables have to be considered, with the present knowledge of cable-making, it may be said that 20,000 volts is the safe limit.

(3) Economical Distribution.—This has to be determined with reference to the conditions to be maintained in the consumer's circuit. These conditions are, as to whether continuous or alternating currents are more adaptable for a particular set of local conditions, or whether the combination of both could be made to meet the widest range, and finally what conditions as to voltage drop have to be maintained. Either for lighting, or in earth returns for electric traction, a very small voltage drop only is permissible.

A number of small electric sub-stations will, from a commercial point of view, be found more economical than would be the case if each were to be a complete generating station. Sub-station plant can be built free from objectionable vibration or noise. It also occupies exceedingly little space. For these reasons it can be located in situations which would be impossible if complete generating stations had to be laid down.

Numerous sub-stations involve lower efficiency in transformation, higher first cost of plant, and heavier attendance charges. On the other hand, a saving is effected both in feeders and distributors, and the efficiency of transmission is increased, due to smaller feeder losses. Any general rule as to the most economical number of sub-stations to employ is impossible. For a particular case of fairly uniform distribution over a large area at a rate of 1,000 K-W. or more per square mile, a radius of distribution of half a mile would be warranted from economical considerations.

Smaller supply densities and in general ununiform distribution will increase the economical radius of supply, and diminish the best number of sub-stations.

With short feeders the further advantage is obtained that the feeder drops are smaller, and the consequent variation of voltage at different parts of the system through different feeders loading up irregularly is largely eliminated, with consequent simplification in switchboards, better service, and more economical running of the plant.

The arrangement of sub-stations has also to be considered in respect to the nature of the load, so that, in the case of the average load, the losses due to friction and hysteresis will be balanced against the C^2R losses.

In general, it may be said that single-phase transmission has had its day. In any scheme, even though designed primarily with a view of lighting distribution, it becomes necessary to take into account probable demands for power. So far, the single-phase motor has not been a success, and in districts where single-phase plant has been laid down, special arrangements are being generally made for the supply of continuous current for power purposes.

The gradual perfection of the generating apparatus, so that current can be obtained reliably at very high voltage, the high efficiency of the trasmitting main, together with the step-down transformers and rotary converter, and the great flexibility of such system, has led many engineers to believe that multiphase transmission with rotary converters and continuous current distribution will be the ultimate system in dealing with large powers over an extended area. The popular formula amongst the more progressive engineers is to use multiphase transmission at a periodicity of 25 to 50, at from 5,000 to 40,000 volts, according to the distance and conditions of transmission.

There is comparatively little choice between two or three-phase currents. The conditions favoring three-phase transmission are in respect to the small amount of copper required, and greater flexibility in the use of transformers. Thus, without increase in complication, the three-phase system requires but three-quarters of the weight of copper necessary for two-phase currents, and the transformers may be connected for six-phase transformation instead of three-phase in dealing with rotary converters—a condition very favorable to practical working.

The theory of the action of the rotary converter has been definitely laid down, and there is at the present day plenty of experience as to its working in practice. The early difficulties experienced have been largely overcome by more careful design both in the prime mover and in the rotary converter itself. It has been found necessary to give attention to the production of constant angular velocity in the prime mover.

In England, on account of the stringent regulations, in connection with the working of tramways, multiphase currents become economical at less distance than in most other countries, since the losses due to transformation are compensated for by the advantages gained by centralization. The only two other multiphase installations in the United Kingdom working are those of Dublin and Middlesborough. There are, however, the greater installations of the Central London Railway, the London United Tramways, and the Glasgow and Metropolitan. When these are completed, it can be fairly said that these installations demonstrate the general feeling amongst engineers, that the multiphase system of generation is the one most likely to give economical results even over comparatively limited areas.

Discussion.—Several of the more notable long distance, high tension plants in the United States were briefly described. The difficulty of synchronizing was referred to by several speakers, and because of this, one or two advocated the use of direct current high pressure generation, and then transformation up to triphase for feeders. The general opinion seemed to be, however, that there was no question about the advantage of the multiphase current as compared with the direct current.

MECHANICAL TRACTION BY ELECTRICITY.

By Granville C. Cuningham, M. Inst. C. E.

In the installation of mechanical traction by electricity on tramway systems, the point to be considered is how this form of traction compares in cost of construction and working with that it displaces; and what are the conditions that make for a high or a low cost of working.

The cost of horse-traction—and by this is meant the cost of horse-keep, wages of grooms, shoeing, veterinary expenses, but exclusive of drivers' wages—may be taken as varying from 3½d. per car-mile in an easily-worked town such as Glasgow, to 5d. per car-mile in a hilly and more difficult town, such as Liverpool. This is the cost of horse-traction arrived at from the working of fairly large systems showing 7,000,000 car-miles annually in Glasgow, and over 4,000,000 in Liverpool. The cost of electric power for traction on the overhead trolley-wire system should, with economical engines, boilers, and heat-saving appliances, be under ½d. per car-mile for an easily-worked level town, and for a more hilly town with steep gradients, but slightly over 1½d. per car-mile. The cost here meant is the cost of all wages, fuel, water, oil, etc., in the power-house, together with the cost of maintenance, repairs, and up-keep of the plant. The cars driven by this power are those weighing about 6½ tons when empty, and capable of seating twenty-six passengers inside. But in order to ensure this low cost of working, every care must be taken in the power-house. In choosing its site, it should be placed close to a plentiful supply of water, where all that is requisite for condensing purposes may be had at a nominal charge, or merely for the cost of pumping. A river, canal, pond, or the sea, would afford what is needed. It should be conveniently situated for the supply of coal from railway line, canal or wharf, so as to save the charge of handling fuel. One shilling per ton saved in cartage would amount to a very considerable sum in a year in a large traction station. But, needless to say, the most important matter is the type of engines, boilers and heat-savers to be used. The writer favors low-speed (70 revolutions) compound condensing engines, such as are built by numerous English firms, boilers of the Lancashire or Galloway type, with Green's economizers.

Note what a large saving is affected when a cost of ½d. per car-mile for power is substituted for 5d.; on a car-mileage of 7,000,000 it means no less a sum than £131,250 per annum! and indicates the source whence the increase of net earnings may be obtained to pay for the heavy cost of electrical installation. The whole cost of working a large electric system, including working charges of all kinds, should be under 5d. per car-mile; but this can only be obtained with a carefully constructed power-house, where the works-cost of the current is cut down to a minimum.

Enough has been said to indicate that, in the writer's judgment, it is to the power-house that the chief attention should be directed in order to ensure the financial success of an electric system. Other parts of the system claim attention, but it is on this that success or failure mainly turns. More money can be lost on the one item of power than would pay all the other working charges, and whether the high potential system with transformers, or the multiple unit system be adopted, the successful working ultimately depends upon having engines and boilers that will do their work with a low consumption of fuel.

Discussion.—A number of records of cost were presented which generally bore out the figures given in the paper. The author's preference for slow speed engines was criticised, although it was generally admitted that they were more economical of coal.

SOME NON-INTEGRATING ELECTRIC METERS.

By Prof. William Edward Ayrton, F. R. S., Assoc. M. Inst. C. E.

Materials.—The five most important metals employed in the construction of electric meters are copper, iron, steel, phosphor-bronze, and some alloy of high resistivity. A few years ago copper of 98% conductivity (Matthiessen's standard) was considered good, now it is stated that copper of 105% conductivity can be obtained commercially from Mouchel of France. The great increase in the electric conductivity has been attributed to greater density of the material; but there seems to be considerable doubt about this, and it is desirable to try whether a still further electric improvement, possibly even a relatively large one, might not be produced by using much greater care in removing the last traces of impurities. It is also important to find out exactly how the variation of resistance with temperature increases with increase in the electrical purity.

Soft iron needles of electrical instruments should have small remanent magnetism and small coercive force, while both these qualities should be large in steel for permanent magnets. A large magnetic improvement has been effected in commercial soft iron during the last few years, and even steel can now be purchased in ingots having a far smaller coercive force than the so-called "soft" iron practically employed for electric apparatus six or seven years ago; and, by constructing the meter so that the magnetic induction is kept low, soft-iron instruments may be used for measuring alternating currents and pressures with fair accuracy. It should be remembered, however, that although the number of turns and the maximum scale reading may correspond with a number of ampere-turns which produce only a small induction with a sine or a flat-wave, such instruments may read wrongly if the wave be peaked. A satisfactory compensation for variation in the frequency is affected by shunting the instrument with a self-induction, and experiments should be made to devise some such device to compensate for the wave having a peak.

The manufacture of steel magnets has much improved during the past few years, as indicated by the following results obtained from tests on steel magnetized with a force exceeding 200:

	Residual Magnetism.	Coercive Force.
1885. Oil-hardened steel tested by Dr. J. Hopkinson	11,300	12
1893. Glass-hard pianoforte wire tested by Prof. Ewing	9,500	45
1898. Molybdenum steel tested by Madame Curie	..	85

This marked increase in the coercive force, which is of great importance in preserving the constancy of permanent magnet types of measuring instruments, has been brought about partly by improvement in the composition of the material, and partly by greater experience having been gained regarding the proper way of hardening magnets. Still greater improvement may certainly be anticipated.

In instruments employing a spring control, and in which, for magnetic reasons, steel cannot be used, phosphor-bronze is the best elastic metal, but it is far excelled by quartz as regards the absence of sub-permanent set. A really satisfactory method of coating quartz with even a metallic layer of sufficient conductance to serve as the flexible electrode for an electro-static voltmeter using a spring control is very desirable, but better still some metallic alloy possessing the mechanical properties of quartz is well worth seeking.

Alloys possessing higher and higher resistivities and smaller and smaller temperature coefficients are being constantly brought to notice, but no one seems to be seeking for a substance with a small temperature coefficient and a small resistivity, although that is the kind of substance that is needed for many purposes, as, for example, to wind voltmeter coils with and the bobbins of moving coil instruments used with a shunt for the measurement of large currents.

Galvanometers.—The moving coil type of instrument has affected a revolution in galvanometry, and where low resistance and short period are desired it greatly surpasses the moving-needle type. No moving-coil galvanometer, however, has yet been constructed that will even indicate the existence of the small currents which certain moving-needle galvanometers will measure accurately. Development of the moving-coil type of instrument is at present limited by the comparative smallness of the field produced by a permanent magnet, the limiting fineness that can be given to the strip of metal used for the suspension, and the slight trace of magnetism that remains in the so-called non-magnetic materials, used in constructing the coil, even after the application of the best method of freeing them from magnetism. In view, however, of the great improvements that have been introduced into moving-coil types of galvanometers during the past few years, and of the fact that a given volume of wire possesses such an enormously greater value in the moving coil than in the ordinary moving-needle type of instrument, it may not be too sanguine to look forward to moving-coil galvanometers rivaling moving-needle galvanometers for all purposes.

Ammeters and Voltmeters.—Instruments depending on the action of one coil on another without iron generally use a working field of about 50. Therefore, since the field on a central station switchboard often exceeds 20, the disturbance may be very great. Indeed, the error arising from the current in the leads alone of such an instrument may be serious. The importance of using copper of much higher conductivity than at present obtainable, so as to employ many more convolutions of wire without increasing either the volume or the resistance of a coil, is here manifest. Some soft-needle instruments have also fields not exceeding about 70, and are, therefore, quite useless for central station work, unless protected in special ways with soft-iron magnetic shields.

The field in which the coil of some moving-coil instruments turn is as high as 1,200, and it might be expected that small stray fields would produce no error. But, as a matter of fact, the iron pole-pieces, and especially the iron core, concentrate the stray field on the coil; so that a stray field of only 0.5 when parallel to the field of the instrument may produce an error of 0.4%, or nearly ten times as great as the ratio of the fields alone would lead one to expect. The employment, however, of an astatic pair of narrow coils without an iron core greatly reduces this error.

For measuring large alternating currents it is desirable to employ a small transformer giving a maximum secondary current of some 10 amperes, which can be easily led to an ammeter at a safe distance from the main cable, and by keeping the resistance of the secondary circuit low, the transformation ratio will not be affected by changes of frequency. The best way at present of measuring small alternating currents is by means of an electro-static voltmeter shunting a non-inductive resistance.

Electro-static voltmeters have practically no errors due to stray magnetic fields, unless they are rapidly alternating. In that case, unless the needle and inductors be properly subdivided, eddy currents may be induced and a disturbing force introduced. The error due to impedance is practically zero, as the capacity of a dead-beat electro-static voltmeter with a 12-in. pointer need not exceed about thirty-millionths of a micro-farad. Pivot-friction and brush-discharge between the needle and inductors introduce the greatest troubles, and it is difficult to obtain as much damping as is desirable. Coating the inductors with mica, enamel, etc., greatly reduces sparking between them and the needle, but not the brush-discharge with an alternating potential difference, and is, therefore, of little practical use. A better method of stopping the brush-discharge than by immersing the whole instrument in oil is much needed.

Megohm-meters.—Direct-reading ohm-meters, measuring up to 50 megohms, are now obtainable, but apparatus is also needed to enable the insulation of an electric-light cable to be tested where laid. At present cable is often supplied which, although possessing only a fraction of the specified insulation, is passed because suitable testing apparatus can be used only in a laboratory.